University of Alberta

Cost Implications of Alternative Tolerance Levels: Non-Genetically Modified Wheat in Western Canada

by

Israel Matthew Huygen ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

in

Agricultural and Resource Economics

Department of Rural Economy

Edmonton, Alberta

Spring 2004

Library and
Archives Canada

Published Heritage
Branch

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque et
Archives Canada

Direction du
Patrimoine de l'édition

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence
ISBN: 0-612-96490-6
Our file Notre référence
ISBN: 0-612-96490-6

The author has granted a non-exclusive license allowing the Library and Archives Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou aturement reproduits sans son autorisation.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.

Canada

ABSTRACT

Modern developments in agricultural biotechnology are leading to the creation of supply chains involving identity preservation (IP) of genetically modified (GM) and non-GM crops. This study defines a basic farm model together with other major features of three Supply Chain Systems for non-GM wheat. System 1 involves elevators which receive both GM and non-GM wheat, System 2 involves designated non-GM only elevators and System 3 entails the use of containers. Agricultural industry specialists are surveyed as to their estimates of differences in incremental costs of IP as the levels of tolerance for GM material within non-GM wheat are varied.

Results suggest that there are alternative methods for managing an IP system for non-GM wheat, that tolerance levels for GM content have an appreciable effect on IP costs, and that on-farm costs are particularly sensitive to different tolerance levels.

DEDICATION

I dedicate this thesis to Kim, my wife, my best friend and my soul mate. Thank-you so much for all of your support, encouragement, patience and love.

To my mom, Agnes Huygen, the best mom in the world.

To my dad, Otto Huygen (1948-1998), who initiated my love for Agriculture through his own love for it; taught me through example that work was something that filled the time between helping people and busyness was not a reason to pass by someone with a flat tire; and that sometimes playing hockey with your kids is the best and most important job of all. Dad, I miss you everyday.

ACKNOWLEDGEMENTS

This thesis is the culmination of efforts made by many people, directly or indirectly. I can't possibly thank everyone who has had a hand in helping me and supporting me through to this point, but I will name a few.

First, I would like to thank God, my Lord and Saviour, who is the reason I live.

Countless thanks to my supervisors Dr. Mel Lerohl and Dr. Michele Veeman for their guidance and patience throughout my thesis preparation. I would also like to thank-you for your keen editing, groovy ideas, and abundant encouragement.

Thank-you to the department staff: Liz, Marilou, Judy, Dawn, and Anna for answering the same questions eighteen times in a row, always with a smile. Also, thanks to Randy for the computer rescues, humour and of course for taking care of Gordie.

In addition to my supervisors, I'd like to thank Dr. Ian Morrison, and fellow die-hard leaf fan, Dr. Scott Jeffrey, for being on my thesis committee (Leafs in 2004).

I extend gratitude to my sources of funding: the Genome Prairie GELS project and the Alberta Agriculture Research Institute, and also to the source of the McBain Scholarship.

I would also like to thank my Dordt friends, Glad Tidings, Happy Homers, Sting and the friends I have made here at the U of A. I would especially like to thank Rich who introduced me to Rural Economy and has been there for me since high school; Wuyang, who has been a great friend and the most selfless colleague I have ever known; and Joffre who is among other things, a great distraction when I need it the most, and the least. Thanks to Brad, Dan, Kristy, Jason Levi, Hendrik, Julies, Gregor, Tara, Jaclyn, Nagses, Turbos, Jake, Laura, Ron, Matt, Wilma, Gaefta, Deb, Sieb, Ang, Nautalota, Mark, Boots, Armstrong, Getu, Jorge, Puff, Xiao Chao, Shane, Jason, Trena, Amanda, Ryan, Gord, Roy, Manny, Chris, Lucy, Scott, Gunilla, Robyn, James, Argaw, Cindy, Jean, Sibo, Lorraine, Jeiji, Smithers, Bentum, Rich, KD, Haarwest, the Daves, Heather, Lisa, Jenny, Pauly, T, Hannah, Martin, Yaastin, Hpile, Norman, the Hip, and of course Wendel.

Finally, I would like to thank all of my family: my wife Kim, Dad, Mom, John, my brothers Adam and Jeremy, my sisters Lisa and Lesley, and Jason, Tanya, Kaleb, Lyric, Dylan and Ethan. Thanks also to all the Weeks family, Ray, Carla, Josh, Nick, Vern, Liza, Victoria and Avry. I love all of you.

Table of Contents

1 Introduction..........1
- 1.1 Background..........1
- 1.2 Problem Statement..........3
- 1.3 Objectives of the Study..........5
- 1.4 Scope of Study..........6
- 1.5 Hypothesis..........6
- 1.6 Organization of Thesis..........7

2 Background and Literature Review..........8
- 2.1 Introduction..........8
- 2.2 Background..........8
- 2.3 Biotechnology and Genetic Modification..........9
- 2.4 Identity Preservation..........11
- 2.5 Previous Studies of Identity Preservation Costs..........13
- 2.6 Gene Bridge Concerns..........17
- 2.7 Kernel Visual Distinguishabilty and Testing for Genetic Modification..........18
- 2.8 Tolerance Levels and Thresholds..........21

3 Methodology and Model Development..........23
- 3.1 Introduction..........23
- 3.2 Approach..........24
- 3.3 The Model..........25
- 3.4 Specific Assumptions..........28
- 3.5 Tolerance Levels..........29
- 3.6 Sub-Model Assumptions..........29
  - 3.6.1 Farm Level Assumptions..........30
  - 3.6.2 Primary Elevator Level Assumptions..........32
  - 3.6.3 Export Elevator Level Assumptions..........33
  - 3.6.4 Containerization Assumptions..........33

4 The Data..........35
- 4.1 Introduction..........35
- 4.2 Data Specification..........36
- 4.3 Questionnaire Development and Application..........38
- 4.4 Summary..........42

5 Analysis and Discussion of Results..........43
- 5.1 Introduction..........43
- 5.2 Farm Level Costs..........43
  - 5.2.1 Isolation Zones..........44

5.2.1.1 Isolation Zones: Comparing Two Potential Zone Practices... 47
5.2.1.2 Isolation Zone Protocol....................................50
5.2.2 Volunteer Control Costs.. 53
5.2.3 Machinery Cleaning Costs..56
5.2.4 On-Farm Cumulative Tolerance Sensitive IP Cost Estimates.. 62
5.2.5 Sensitivity Analysis.. 65
5.3 GM Testing..71
5.4 Primary Elevator Level Costs...78
5.4.1 Mechanical Cleaning Costs..80
5.4.2 Capital Expenditures..83
5.4.3 Cumulative Estimates for Incremental IP Costs at the Primary Elevator..86
5.5 Incremental IP Costs at the Export Elevator Level 90
5.5.1 Mechanical Cleaning Costs..91
5.5.2 Capital Expenditures..93
5.5.3 Cumulative Export Elevator Incremental IP Costs............95
5.6 Containerization.. 99
5.7 Total Incremental Tolerance-Sensitive IP Costs for Three Supply Chains..99
5.8 Aggregate Costs for Identity Preserved CWRS Wheat: From Farm to Ship.. 102
5.8.1 Non-Tolerance Sensitive Costs for CWRS Wheat (Systems 1 and 2).. 103
5.8.2 Costs of Containerization (Exclusive of Tolerance-Sensitive Costs).................. 105
5.8.3 CWRS Wheat System Costs, Including Tolerance-Sensitive Costs.................................108
5.9 Respondents' Views of Feasible GM Tolerance Levels......................... 110

6 Conclusions and Discussion..113
6.1 Conclusions and Discussion...113
6.2 Limitations of the Study...117
6.3 Suggestions for Further Research...119

Bibliography.. 121

Appendix A: Survey Questionnaires...126

Appendix B: Genetic Modification Details...147

List of Tables

Table 3-1: Tolerance Levels Considered and Rationale for Selection.................... 29
Table 3-2: Stated Assumptions for Developing Research Models........................... 34
Table 4-1: Data Estimation: Survey Participants..42
Table 5-1: Average Estimated Isolation Zone Width and Number of Sides of Field Requiring Isolation... 45
Table 5-2: Mean Costs of Isolation Zones Across Tolerance Levels..................... 45
Table 5-3: Mean Cost Comparisons for Two Different Isolation Zone Practices Across Tolerance Levels in $ per Tonne................................ 49
Table 5-4: Area of Isolation Zone (acres) per 160 acre field............................51
Table 5-5: Costs of Cultivating Isolation Zone..52
Table 5-6: Comparing Two Methods of Isolation Zone Management Under Different Parameter Specifications for Zone Width and Sides per Field Requiring Isolation Total Cost of Isolation Zone per Field.....53
Table 5-7: Mean Incremental IP Costs of Volunteer Control...............................54
Table 5-8: Estimated Costs of Cleaning Farm Equipment Across Tolerance Levels...61
Table 5-9: Tolerance Sensitive IP Cost Summary at the Farm Level. Estimated mean costs as tolerance varies ($ per tonne)...............................62
Table 5-10: Farm Level ANOVA Summary Statistics. Testing Mean Estimates for Significance Among Tolerance Levels...................................... 64
Table 5-11: Farm Level Confidence Interval Summary Statistics. Testing Mean Estimates for Significant Difference from Zero........................... 65
Table 5-12: Sensitivity Analysis: Incremental Farm IP Costs.................................70
Table 5-13: Mean Incremental Costs of GM-Tests for Wheat............................... 72
Table 5-14: Plausible GM-Testing Protocol and Costs Across Tolerance Levels System 1: Elevators Receive Both non-GM and GM Wheat......... 74
Table 5-15: Plausible GM-Testing Protocol and Costs Across Tolerance Levels System 2: Elevators receive Only non-GM Wheat.......................75
Table 5-16: Plausible GM-Testing Protocol and Costs Across Tolerance Levels System 3: Containerization...78
Table 5-17: Mean Costs of Mechanical Cleaning at the Primary Elevator System 1: non-GM and GM wheat received within the same elevator...81
Table 5-18: Mean Costs of Mechanical Cleaning at the Primary Elevator System 2: Elevator designated to receive only non-GM wheat.......82
Table 5-19: Mean Incremental IP Costs of Capital Expenditure at the Primary Elevator System 1: non-GM and GM wheat received within the same elevator...84
Table 5-20: Primary Elevator Level ANOVA Summary Statistics. Testing Mean Estimates for Significance Among Tolerance Levels.......................85
Table 5-21: Primary Elevator Level Confidence Interval Summary Statistics Testing Mean Estimates for Significant Difference from Zero........ 85

Table 5-22: Mean Incremental Cost Estimates at the Primary Elevator Level
System 1: non-GM and GM wheat received within
the same elevator..........86
Table 5-23: Mean Incremental Cost Estimates at the Primary Elevator Level
System 2: Elevator designated to receive non-GM wheat
and no GM wheat..........86
Table 5-24: Mean Incremental IP Cost Estimates of Mechanical Cleaning at the
Export Elevator System 1: non-GM and GM wheat received
Within the same elevator.......... 92
Table 5-25: Mean Costs of Capital Expenditure at the Export Elevator
System 1: non-GM and GM wheat received within
the same elevator..........93
Table 5-26: Export Elevator Level ANOVA Summary Statistics. Testing Mean
Estimates for Significance Among Tolerance Levels..........94
Table 5-27: Export Elevator Level Confidence Interval Summary Statistics.
Testing Mean Estimates for Significant Difference from Zero.......... 94
Table 5-28: Mean Incremental Cost Estimates at the Export Elevator Level
System 1: non-GM and GM wheat received within
the same elevator..........95
Table 5-29: Mean Incremental Cost Estimates at the Export Elevator Level
System 2: Elevator Designated to receive non-GM wheat
and no GM wheat..........95
Table 5-30: Tolerance Sensitive Costs For Three Supply Chain Systems.......... 100
Table 5-31: Costs from Farm to Port for non-GM IP CWRS Wheat: Elevator
Systems 1 & 2 (Not Including Tolerance Sensitive IP Costs)..........104
Table 5-32: Costs from Farm to Port for non-GM IP CWRS Wheat
For Containerization, Supply System 3
(Not Including Tolerance Sensitive IP Costs..........106
Table 5-33: Total Aggregate Costs, CWRS: Farm to Port
Comparison of Three Alternate Supply Systems
Across Tolerance Levels..........108

List of Figures

Figure 3-1: Research Model: Three Alternate Supply Chain Systems. Non-GM Wheat, From Farm to Port....................27
Figure 4-1: Cost Points Sensitive to Genetically Modified Content Tolerance levels in Three Supply Chains.................... 38
Figure 5-1: On-Farm Tolerance Sensitive Identity Preservation Costs....................63
Figure 5-2: Sensitivity of Farm IP Costs to Yield Variations....................71
Figure 5-3: Primary Elevator Tolerance Sensitive IP Costs (System 1: Segregation Within Elevator).................... 87
Figure 5-4: Primary Elevator Tolerance Sensitive IP Costs (System 2: Designated non-GM Elevator)....................88
Figure 5-5: Primary Elevator Tolerance Sensitive IP Costs (Systems 1 and 2)....................89
Figure 5-6: Export Elevator Tolerance Sensitive IP Costs (System 1: Segregation of non-GM and GM Wheat within Elevator)....................96
Figure 5-7: Export Elevator Tolerance Sensitive IP Costs (System 2: Designated to Receive non-GM Wheat only)....................97
Figure 5-8: Export Elevator Tolerance Sensitive IP Costs (Systems 1 and 2)....................98
Figure 5-9: Incremental Tolerance-Sensitive IP Costs for Three Supply Chains.... 101
Figure 5-10: Aggregate Cost Comparison of of an IP Elevator System and an IP Container System for CWRS Wheat (Not Including Tolerance-Sensitive Costs)....................107
Figure 5-11: Total Aggregate Costs, CWRS: Farm to Port....................109
Figure B-1: Bioengineered Insertions for Roundup Ready® Soy.................... 147

CHAPTER 1

Introduction

1.1 Background

Genetically modified (GM) crops are a reality and of increasing importance in agriculture today. This has become an important consideration for Canadian agriculturalists, and for the markets that purchase Canadian agricultural products.

The first significant GM crop registered for commercial production in Western Canada, in 1995, was a herbicide tolerant (HT) variety of canola engineered to be resistant to the non-selective glyphosate herbicide, Roundup®. This canola was dubbed Roundup Ready® (RR) canola. Since that time, adoption of HT canola has increased to account for more than 80 percent of all canola acres grown in Western Canada (Mauro and Van Acker 2003; Grenier, 2003). GM corn and soybeans have also been grown extensively in Canada, specifically in southern Ontario. These include RR varieties of both corn and soybeans (in the vein of canola), while Bt (Bacillus thuringiensis) varieties have also been developed for corn that is resistant to the insect pest, the European corn borer. Additional traits that are being researched and may be introduced into agricultural crops using genetic modification include disease resistance, improvements in nutritional value and the capacity for crops to withstand a variety of weather conditions such as drought, frost and flood (Food Future 2002).

Many Canadian farmers have adopted GM crops for the potential advantages of these crops to cropping rotations. In spite of the fact that Canada has approved a number of particular GM varieties, and subsequently, the adoption of many of these by Canadian farmers, Canada's export markets have shown a significant degree of hesitancy in accepting GM technology (Philips and Foster 2000). This apprehension hinges on the worldwide perception by many consumers that food products from genetically modified (GM) crops may be unhealthy, have harmful effects on the environment, or be associated with ethical or social objections (Veeman, 2001). One consequence is an increase in demand for additional regulation of the production and marketing of GM crops.

Round up Ready® wheat has been submitted for regulatory approval in Canada. There is much current debate about the prospect of GM wheat. This may be because, unlike corn, canola meal, and soybean meal, which are primarily used as feed for livestock, wheat is primarily a human consumable product. "Wheat is much more sensitive to the issues surrounding food safety because it is part of our daily bread." (Demeke, 2002). If RR wheat does indeed receive regulatory approval, there are likely to be market consequences for Western Canadian wheat.

> "Our customers are telling us they have very serious concerns or are flat-out opposed to GM wheat...While this opposition may have nothing to do with science, the customer is always right." -- (Bair, 2002)

Whether or not consumer concerns are scientifically based, consumer attitudes dictate demand. The issue at hand is not food safety, but rather, consumer acceptance of the product (Wisner, 2002). If a significant number of consumers do not prefer GM wheat, this will have production and marketing consequences.

Canada is among world's largest producers and exporters of wheat. The Canadian Wheat Board (CWB) is the sole marketing agent for exported wheat or wheat for human consumption that is produced by Western Canadian producers. Western Canada is acknowledged internationally as one of the world's premier suppliers of high quality wheat. Wheat is grown on over 20 million acres in the western prairies, producing over 20 million tonnes annually. Almost 19 million tonnes of wheat is sold annually to more than 70 countries generating between $4 and $6 billion US dollars in sales revenue and accounting for over 18 percent of the world's exported wheat, the 2nd highest in the world (CWB, 2003). The fact that Canada is such a large player in the export market makes the pending commercialization of GM wheat a major issue within Canada's agriculture industry.

1.2 Problem Statement

According to reports from the CWB, buyers representing approximately 80 percent of Canada's current export markets for wheat have indicated that they would not purchase GM wheat (Grenier, 2003) if Canada grew this. Further, several countries express reluctance to import food products derived from GM commodities, leading to increased pressure for commodity segregation, as through identity preservation (IP) systems. Nonetheless, whether the regulators license GM wheat or not is not dependent upon market acceptance. If GM wheat varieties meet the safety and quality standards for food, feed and environment, licensing is expected to occur.

With licensing, and if GM wheat has some agronomic advantages, production of GM wheat for feed wheat markets may well occur, despite the potential loss of export markets.

It is clear that with licensing of GM wheat, an IP system or systems will need to be developed in order to meet the needs of consumers who demand wheat that is non-GM. The high volume throughput system of the Canadian wheat industry that has been developed over the last century or so has grown out of the cost advantages of the efficiencies of automation and economies of scale. There are likely to be increased marketing complexities and costs with changes in handling systems to provide IP systems for those crops where GM varieties are grown in order to provide assurance to those end-users specifying non-GM wheat (Gosnell, 2001).

It is expected that IP will add costs to all levels of the supply chain. These costs have been estimated for several differing IP supply chains. However, it is difficult to estimate the costs associated with IP in a non-GM system if the allowable tolerance for adventitious co-mingling (mixing with GM grain) is not known. Under various tolerance levels, costs could vary significantly.

The underlying challenge that Western Canadian producers, handlers and marketers of wheat face is how can non-GM wheat be identity preserved in order to maintain current market share for export wheat, and how much will such IP systems cost? Tolerance levels for GM content within non-GM wheat consignments set by different import countries are not standard, and it is therefore an important question as to how different tolerance levels may affect the costs of IP. This study is directed to this set of questions.

1.3 Objectives of the Study

The principal objectives of this study are to 1. Identify particular costs of IP systems for non-GM wheat in order to assess which of these cost components are the most sensitive to various tolerance levels; and 2. Estimate the effects of varying tolerance levels on specific tolerance-sensitive IP costs. The identification and analysis of cost-sensitive IP systems applies from the farm level to export port. Tolerance-sensitive cost points will be identified within three potential non-GM IP systems:

1. System 1: Primary and terminal export elevators receive non-GM and GM wheat within the same facility and maintain the integrity of the non-GM IP wheat within the elevator system to the export port.
2. System 2: Certain grain-handling primary and export elevators are designated to receive only non-GM IP wheat and no GM wheat in the handling and shipment of wheat to the export port.
3. System 3: Containerization of non-GM IP wheat applies to shipment of wheat via sealed containers from the farm to the export port, by-passing the elevator system.

A primary underlying assumption of the study is the scenario that GM wheat is approved for release in Western Canada, in the Canadian Western Red Spring (CWRS) wheat type, which is the major type of bread wheat exported from Canada. Additionally, it is assumed that some 50 percent of the current amount of CWRS that is exported is non-GM.

In summary, the main objectives of the study are:

1. Determine the cost components of specified selected alternative supply chain systems that are most sensitive to variations in tolerance levels.
2. Determine how these specific costs are affected by various tolerance levels
3. Compare costs across tolerance levels for each of three specified IP supply chains.

1.4 Scope of Study

The study focuses on three supply chains for CWRS wheat based on Central Alberta practices and averages for production, handling and shipping to the port of Vancouver. The costs are estimated from the farm to the point that the wheat is loaded onto a ship at port. Cost estimations assume that the IP procedures undertaken at each stage in the supply chain are successful. Hence, liability or insurance costs associated with the risk of adventitious contamination are not estimated in this study.

1.5 Hypotheses

The main hypothesis for this study is that IP costs will increase as tolerance levels for GM content in non-GM wheat decrease. Correspondingly, the costs of IP and tolerance levels are hypothesized to be inversely related. Lower tolerance levels require added scrutiny and care at each level of the supply chain, which is expected to translate to added costs at lower tolerance levels. It has even been suggested that IP costs could increase exponentially with each percentage decrease in the tolerated level of foreign genetic material products (Sorenson, 2001). A related hypothesis is that the three supply chain systems that are being considered for handling non-GM IP wheat will differ in their sensitivity to particular GM tolerance levels.

1.6 Organization of Thesis

Chapter 2 presents an overview of some background information and literature pertaining to the issues involved with biotechnology and IP. The development and description of the approach used in this study, as well as the context for the model, is elucidated in Chapter 3. The data requirements and specification as well as the development of the questionnaires and interview procedures are explained in Chapter 4. Chapter 5 presents the analysis and discussion of the results of estimates while in Chapter 6, the final chapter, conclusions of the study, limitations of the study and suggestions for further research are discussed.

CHAPTER 2

Background and Literature Review

2.1 Introduction

This chapter provides background information on biotechnology in agriculture and looks at some of the effects that the advent of genetically modified (GM) crops is expected to have on identity preservation (IP). Additionally, selected previous studies pertaining to the economics of non-GM crops and IP systems are overviewed.

2.2 Background

To this point agricultural biotechnology has been applied to redesign the genetic makeup of plants and other organisms in order to reduce input costs, increase yields, and protect against diseases and insects. Crops with genetically modified (GM) input traits such as herbicide tolerance including Roundup Ready® (RR) crops and insect resistance in Bt (Bacillus thuringiensis) corn varieties, are part of what has been described as the first wave of GM agricultural products. The second and third waves are projected to focus on output traits and industrial crops respectively (Green and Salisbury 2001).

The introduction of GM crops has brought the issue of food safety in the grain industry to a new and complex level. Since the introduction of GM crops in 1995, demands on the international agri-food system for the quality assurance on food products have become greater. The European Union (EU) has been particularly cautious about the introduction of GM products, due in part to previous food safety scares involving salmonella, Mad Cow Disease (BSE) and Foot and Mouth Disease (Hobbs and Plunkett, 1999). The skepticism surrounding GM crops and food is not limited to EU consumers and policy makers, but includes many other consumers, producers, processors and other participants in the food chain in various countries around the globe. Reasons for resistance vary from scientific and environmental concerns to cultural and philosophical beliefs that genetic modification should be avoided.

Monsanto Inc., a large St. Louis based chemical company, has recently developed herbicide tolerant varieties of wheat, specifically Roundup Ready® (RR) wheat. This is considered to be closer to commercialization than other possible GM wheat varieties. Regulatory decisions regarding the release of RR wheat have not yet been made.

2.3 Biotechnology and Genetic Modification

The term "biotechnology" was initially used in 1919 by Karl Ereky to denote the interaction of human technology and biology (Cramer, 2000). However, currently biotechnology is commonly considered to involve more recent scientific advances involving transgenics, also called genetic engineering. Transgenics involves the transfer of DNA from one organism to an organism of a different species. This is commonly known as genetic modification. The common use of the term "genetic modification" as referring only to genetically engineered products may be scientifically misleading. Virtually all crops that are grown have been genetically modified over time through various traditional breeding methods. However, for the purposes of this paper, genetically modified (GM) crops will refer to crops that have been genetically engineered. This is consistent with the common use of the term by the media and public. Based on this use of the term GM, an organism is considered to be GM when genetic material from a different species is inserted into its DNA sequence. Plants that are grown from the seed produced by GM crops also contain GM material. The resistance to herbicides and pests, such as with RR crops and Bt corn, is accomplished through the production of a novel protein that is determined by the inserted DNA sequence.

In soybeans, RR is the only GM trait, or event, which is present in actively grown commercial varieties (Spurrier, 2003). The first varieties of GM wheat to be considered for licensing involve only the RR trait (Smith, 2003). Due to the similarities between GM RR soybeans and GM RR wheat, the same type of tests currently used for testing for the presence of GM content in soybeans, are expected to be used to test for GM content in wheat. Crops that have more than one commercialized GM event require additional testing for non-GM IP programs. The GM tests that are currently used in non-GM IP soybean programs and are likely to be used in non-GM wheat programs are outlined in Section 2.7.

Although it is probable that RR CWRS wheat will be the first GM wheat commercialized, it will not be the first herbicide tolerant (HT) wheat to receive regulatory approval. Clearfield® wheat is a HT wheat developed through mutagenesis, a non-transgenic process. This type of wheat has received regulatory approval, is registered for commercial production in Western Canada (BASF, 2003), and is expected to be commercially available in 2004. Clearfield® wheat is resistant to imidazalone, the active ingredient in BASF's wheat herbicide Adrenalin®. Clearfield® brand varieties of canola, maize, rice and now wheat, have been introduced around the world and have not been subject to the same regulatory obstacles as GM crops because they are not considered to be genetically modified. Thus, Clearfield® varieties do not pose a threat to any non-GM IP wheat system that is adopted in Western Canada.

2.4 Identity Preservation

Identity Preservation (IP) is a management system that is designed to distinguish the source and nature of products as they move through the supply chain (Buckwell et al. 1998). IP systems abide by stringent protocols for production, handling, and testing procedures that require documentation from the producer to the end user (Dobson, 2002).

The term IP, and the process and systems that it entails, is not a new concept. IP is practiced in the production of crops with various distinctive characteristics such as certified seed, malt barley, white corn, food grade soybeans, organically produced crops, or crops with a specific oil composition (Kalaitzandonakes and Maltsberger, 1998).

Identity preservation has become increasingly important with specialty crops that have been developed to meet the demands of particular market requirements that involve features such as specific oil content, protein levels or other desirable characteristics. With the advent of GM crops, however, additional motives for IP arise out of the desire to maintain the segregation of GM crops or of non-GM crops, or to keep certain GM crops from entering into the commodity system where the GM trait is not wanted. In order to maintain purity of a crop, regardless of the motivation, the supply chain system must minimize adventitious co-mingling. Supply chain systems necessarily involve several stages, such as farms and elevators or containers, as well as transportation vehicles such as trucks, trains and ships. Each stage of the production and handling system must be able to maintain the identity of the IP crop in question, giving the necessary attention to sources of potential contamination.

Identity preservation adds costs to supply chain systems. A number of studies have analyzed the additional costs that IP processes add to supply systems. Studies have varied widely in their approach and objectives, which has led to a range of estimates for IP system costs. IP cost estimates for grain crops have ranged from $10 to $50 per tonne (Roederer et al, 2000). The wide range of estimates can be partially attributed to factors such as which particular crop is in question, what supply systems are considered and what stages of the supply chain are considered. Assumptions made in each study regarding the production volume of the IP crop or the adoption rate of certain GM technologies can also lead to a wide range of estimates for IP costs. An additional contributing factor to differences in IP cost estimates is what type of IP conditions are considered. Roederer et al. (2000) distinguish three different plausible IP conditions within the framework of GM crops: voluntary IP of non-GM products, voluntary IP of GM products and compulsory IP of GM products. An additional reason that previous studies have given varying estimates of IP costs is that threshold levels for contamination differ for different crops and different IP systems. Some previous studies are discussed in Section 2.5.

This study focuses on the voluntary IP of non-GM products, namely, non-GM wheat. At this time, systems of voluntary IP of non-GM crops are prevalent since most of the currently commercialized GM crops have input traits that benefit the producer, but have no direct benefit to the consumer (Buckwell et al., 1998). Consumers are not willing to pay extra for input–trait GM crops (and indeed may expect to have discounted prices for these). However, consumers may be willing to pay premiums for products that are certified as identity preserved non-GM. This study focuses on the derivation of estimates of IP costs that are sensitive to different tolerance levels of GM content within non-GM IP systems. Tolerance levels and thresholds are discussed further in Section 2.8.

2.5 Previous Studies of Identity Preservation Costs

Several studies have analyzed IP and segregation costs for a number of different crops using different approaches and for various sections of the supply chain. Some of the different methodologies have included surveys of elevator managers, use of cost accounting methods and application of simulation modeling. The costs of IP estimated in various studies have ranged from U.S. $0.01 to $0.72 per bushel (Wilson and Dahl, 2002), which calculates to CDN $0.50 to $35.75 per tonne.

Several previous studies deal with wheat or related commodities, or use methods that appear applicable to a study of non-GM IP wheat costs. A study done at the University of Illinois by Bender et al. (1999) analyzed a supply chain identified as a potential system for handling specialty oilseeds with potential to identity preserve non-GM crops. The estimates for the added costs of IP were U.S. $0.17 and $0.48

per bushel for high-oil corn and non-GM HT soybeans respectively. These costs translate to CDN $8.92 and $25.19 per tonne (US $1 = CDN $0.70; average exchange rate, Jan.-Sept. 2003). Lin et al. (2000) adapted the study by Bender et al. (1999) to arrive at non-GM segregation estimates. The results from this study suggested that the costs for a non-GM IP program could be higher than the estimates of IP for specialty crops. Modifications made to the initial study included adjustments for GM testing costs, which would be higher than testing for oil content.

Maltsberger and Kalaitzandonakes (2000) studied "hidden" costs in IP supply chains such as lost opportunity costs at the primary elevator level. These authors suggested that there might be loss of a margin if local production of commodity crops, previously ground for feed and resold by the elevator, were replaced by IP crops. Assuming that these IP crops are not ground and resold, the opportunity would be removed for additional elevator earnings in such ground feed markets. Other suggested margin losses include under-utilized storage, and surrendering of grain at inopportune times so that the elevator would lose the potential to capture the benefit of holding grain for carrying spreads.

Bullock et al. (2000) estimated costs of non-GM segregation and IP for soybeans in the United States using cost accounting methods. These authors estimated that IP of non-GM soybeans would cost between U.S. $0.30 and $0.40 per bushel, which converts to CDN $15.75 to $20.99 per tonne (US $1 = CDN $0.70). This study focused on the supply chain from seed to export and included GM testing costs, mechanical cleaning costs and "reshuffling" costs of the grain handling system due to additional segregations. One conclusion was that the major cost would in fact be the "reshuffling" and reorganization of the U.S. grain handling system.

Vandenburg et al. (1999) based estimates for IP involving two alternative segregation strategies including designated elevators, which would not receive GM crops, and elevators which would segregate GM and non-GM within the same facility. It was concluded that using designated facilities for IP crops could become the more efficient of the two systems as the costs of IP increased.

In his MSc. study, Gosnell (2001) highlighted the costs of three potential segregation alternatives for handling non-GM wheat. The three systems included:

1. Designating a high throughput elevator as non-GM only,
2. Designating multiple small wooden elevators to handle non-GM grain only, and
3. Segregating non-GM and GM wheat within elevators.

The study assumed that if GM crops such as RR wheat were commercially grown in Canada, a segregation system would be necessary in order to maintain access to foreign markets that currently purchase Western Canadian wheat, due to resistance to GM foods. The segregation alternatives noted above were assessed under adoption rates of 20, 50 and 80 percent, in terms of the proportion of acres that each farmer would dedicate to RR wheat. Each system was also examined under different demand scenarios for non-GM wheat, specifically, 60,000, 120,000 and 180,000 tonnes demanded within a specific region in southern Manitoba. A decision-making model was used to simulate the managerial processes of producers and grain handlers in segregating non-GM wheat.

Gosnell's model results indicate that segregation within elevators was almost always the low-cost option under the given scenario. However, further assessment of the potential risk of contamination, not factored into the original model, indicated that this low-cost option was not always feasible.

A major limitation of Gosnell's study was that IP costs were only estimated at the producer and handling levels, to the point that grain would be loaded on to rail cars to be shipped to port. Recommendations for further study suggested that estimating the IP costs for the remainder of the supply chain would be beneficial.

A study by Wilson and Dahl (2002) used a stochastic optimization model to assess optimal strategies for testing for GM content in non-GM wheat. The model was used to estimate a risk premium that sellers of non-GM wheat would require as the incentive to segregate non-GM wheat in the presence of GM wheat. Testing costs, rejection costs and risk premium were all estimated for a base model representing a grain export supply chain system. Costs, premiums and risk were all concluded to increase as tolerance levels decreased. Including a premium for risk, premiums increased from U.S. $0.0145 under a 5 percent GM-tolerance scenario to $0.0425 per bushel at a 0.5 percent tolerance level. These costs calculate to CDN $0.76 and $2.23 per tonne respectively (US $1.00 = CDN $0.70). The authors also concluded that the optimal testing strategy was to test every fifth outgoing unit when loading at the primary elevator and every unit loading at the export elevator.

A consulting report (Sparks Companies Inc. 2000) identified IP systems in North American agriculture. Estimates were made of costs of IP for several grains in

Canada and the U.S. Variations in tolerance levels for GM content within non-GM grain were not considered.

2.6 Gene Bridge Concerns

In any IP system, the stages of any supply chain where co-mingling can occur must be identified and actions must be taken in order to avoid or minimize co-mingling at those stages. Most of the co-mingling concerns relate to actual physical mixing of crops through equipment or other means. Additionally, volunteer crops need to be controlled through chemical or tillage methods. Besides physical co-mingling concerns, volunteer plant emergence concerns become a greater issue with GM crops, particularly in the case of herbicide resistance and herbicide resistant (HT) volunteers. With the advent of GM crops, other issues involving "gene bridges" also become a concern (Mauro, 2003). A "gene bridge" exists when genes are able to "drift" into adjoining areas or different fields leading to cross-pollination or "out-crossing" with other plants or crops. Previous to the introduction of GM crops, gene bridges received less attention and were source of less concern. With GM crops there is an issue of contamination through pollen flow (CWB, 2002). DNA material can cross from one plant to another through pollen flow, and if the DNA that crosses over is genetically modified, the plant that is pollinated by the pollen from the GM crop will produce seeds that also carry the GM trait. As a result, isolation zones need to be implemented in production of non-GM wheat in order to minimize out-crossing of GM wheat to non-GM wheat.

Wheat is a self-pollinating crop. The incidence of it being pollinated by another plant is usually less than 1 percent. Although out-crossing is minimal in wheat, wheat pollen has been detected as far as 27 metres from the source (Hucl and Matus-Cadiz, 2001). However, Hucl and Matus-Cadiz (2001) also found that 95 percent of the out-crossing that was present occurred within 6 metres of the pollen source for some varieties and only 0.7 metres for other varieties. At 20 metres the gene flow rates were less than 0.1 percent.

Based on experimental evidence, isolation zones can be used between GM and non-GM wheat cultivars to minimize out-crossing, resulting in gene flow that can be kept below specified threshold levels. However, for any pollen-shedding crop, a zero gene flow assurance is not possible (Waines and Hedge, 2003). The Canadian wheat industry would be greatly impaired if GM wheat was commercially grown and foreign markets maintained a zero tolerance stance.

2.7 Kernel Visual Distinguishability and Testing for Genetic Modification

Kernel Visual Distinguishability (KVD) is an important component of the Canadian registration, grading and quality control system. If a variety of wheat is to be registered in Canada, it first goes through analysis for end-use quality, performance, and resilience and it must be able to be demonstrated that the proposed new variety is equal or better than the criterions for its class (CGC & CWB, 2000). A new variety must also not conflict with the principle of kernel visual distinguishability since this has long been used in Western Canada to allow wheat from different classes to be visibly identified as being different from each other.

There are currently seven different Western Canadian wheat classes, each having distinct physical features that enable it to be visually identified. When the type of wheat is determined, assumptions about its other characteristics can be safely made, according to the registration guidelines that are in place. However, with the introduction of GM wheat, the KVD system, as it stands, will not be able to determine differences between GM and non-GM wheat. Samples of CWRS wheat that are visually identical, still having indistinguishable end-use qualities and performance attributes, will no longer be guaranteed to be consistent in every respect. The genetic content within the samples could differ if there was genetically modified content present in any of the wheat. For this reason, GM testing becomes a necessity where non-GM wheat is demanded.

With the introduction of GM crops and the subsequent demand for non-GM products, methods for testing the GM content in non-GM consignments have been developed. For an IP system to be effective, testing the IP product for GM content gives credibility to the IP system. Testing for GM content allows the supplier of non-GM products to assure the purchaser that GM grain did not contaminate the non-GM consignment, and that the purchasers' threshold requirements are fulfilled. In order o enable the labeling of products as non-GM, measurement techniques must be able to establish whether the level of GM content in a sample is within the tolerance level and below the threshold for GM content that a customer specifies.

Presently, testing for the presence of GM content involves testing for a specific event or trait within the crop in question. Currently soybeans have only one GM trait that is commercialized in actively grown varieties (Spurrier, 2003), leading to simplified testing for only that one trait. Other crops such as corn and canola have more than one GM trait that has been commercialized in different varieties adding to the complexity of GM testing for those crops. Additionally, some varieties have two traits "stacked" in the same plant (for example, corn containing both Bt and liberty-link[1] (LL) genes). It is probable that wheat will have only one GM trait commercialized (RR) initially, leading to similar one-trait testing as with soybeans (Smith, 2003).

Essentially, there are two ways of testing for GM content in crops. A specific GM test can either test for the presence (and quantity present) of GM DNA, or for a novel protein that is only produced by a crop that has been genetically modified to produce that certain protein. There are three different types of GM tests that are typically used for testing for GM content in soybeans.

One type of GM test is termed a “strip test”. These are quick, inexpensive, and easy to use. They test qualitatively for the presence of the CP4 (RR) protein. That is, they provide only a positive or negative indication as to whether or not the protein is present in a given sample. A sample is taken from a given shipment and the test can be completed in less than ten minutes. The test can detect as little as one single CP4 enhanced soybean among 1,000 (Harris, 2002). The sample is blended (ground) for less than a minute and then shaken with water for less than a minute. A pipette or dropper is used to transfer some of the solution into a test tube and a test strip is placed in the tube (Neogen, 2001). After several minutes, the strip will indicate whether the CP4 protein is present or not.

---

[1] Liberty Link (LL) crops contain the LL gene making the crop resistant to the herbicide Liberty®.

The ELISA (enzyme-linked immunosorbent assay) test is also called a plate test. This is a quantitative test in that can specify the level of GM content in a given sample. The plate test takes from two to six hours of time and is more laborious and expensive than the strip test. ELISA tests, similar to strip tests, test for genetically modified proteins in a sample.

Strip tests have the benefit of being fast and inexpensive, but the fact that they cannot quantify the amount of GM crop present is a disadvantage. ELISA plate tests have the benefit of being able to quantify the amount of genetically modified content in a sample.

Although there are no international or national standards for testing requirements concerning the detection of GM material, the test that is used in export shipments is the PCR (polymerase chain reaction) test. This test is used because it is the most sensitive and accurate test available to quantify GM content in non-GM products (Fowler, 2003). The PCR method test uses enzymes that synthesize DNA in combination with minute sections of DNA that uniquely match those of the GM trait of interest. If the targeted DNA sequence is present in the sample being tested, the PCR test will be able to indicate the percentage of the sample that is GM. The PCR test is extremely sensitive, which can lead to false positive readings if the test is not conducted with utmost care (Sundstrom et al., 2002).

2.8 Tolerance Levels and Thresholds

In the context of this study, a GM tolerance level refers to the amount of GM wheat that is tolerated in non-GM wheat by customers for Canadian wheat, expressed as a percentage. Five tolerance levels are considered in this study: 5 percent, 3 percent, 1 percent, 0.5 percent and 0.1 percent (see Section 3.5). The effects that these tolerance levels have on the costs of marketing non-GM wheat are the focus of this study. From the perspective of the grain industry, "A tolerance for non-GM is referred to as the maximum allowable GM content to still be considered non-GM," (Wilson and Dahl, 2002). A similar term, threshold, is often used in the context of allowable GM content. Threshold refers to a point that must be exceeded before a given effect is elicited. The threshold is the set point at which non-GM wheat would no longer be considered non-GM, thus, being rejected by the customer. In the context of this study, threshold and tolerance both refer to an expressed percentage of allowable GM content in non-GM products.

One of the reasons that previous studies of IP costs have varied so widely in their cost estimations can be attributed to unspecified tolerance levels for GM content, or other types of undesired contamination. With the exception of Wilson and Dahl (2002), most studies do not consider specific tolerance levels in their cost estimations. In our study, variations in tolerance levels are the focus of an economic assessment of IP systems for non-GM wheat.

CHAPTER 3

Methodology and Model Development

3.1 Introduction

This chapter addresses the development and explanation of the approach used in this study as well as the framework for the model. The development of a conceptual model is necessary to specify the basis for estimates of costs that would be incurred in particular identity preservation (IP) systems for non-GM wheat. This conceptual model is based on three wheat supply chain systems as the foundation for identity preservation of non-GM wheat. Each supply chain begins at the farm and carries through from wheat production to the port of export where it is loaded onto ocean vessels. The cost points, which are sensitive to varying tolerance levels for GM content within non-GM consignments, are identified, and the costs are estimated within the framework of the basic supply chain models. The cost estimates are gathered through interviews with a range of people within the grain industry who are knowledgeable with IP practices at specific points in the alternate supply chains. Each interviewee is presented with certain assumptions regarding the framework for the model, and is asked to give estimates for the supply chain stage with which they are familiar, based on the given model assumptions that are presented to them. The nature of each IP supply chain and the assumptions that underlie the approach and the model are outlined.

3.2 Approach

This study focuses on developing cost estimates for three alternate supply chain systems within which identity preservation of non-GM wheat is maintained from the farm level to export port, under varying standards of threshold contamination levels. Thus the approach focuses on supply chain components that are expected to vary with, and be sensitive to, different tolerance levels for GM wheat within non-GM wheat consignments. The costs of alternate tolerance levels, within three alternate supply chains, are assessed relative to the current supply system, within which there does not exist an IP system for non-GM wheat. The current situation, prior to licensing for commercial release of transgenic GM wheat, is viewed as the base case.

Cost estimates are based on expert assessments relative to five specified tolerance levels within the three supply chain alternatives. Identification and documentation of costs that are sensitive to the various tolerance levels provides the data for an analysis to assess the least cost supply chain alternative for each tolerance level. The data was gathered through interviews patterned by using a structured survey. Interviewees from different sectors of the wheat industry were asked to give their best estimates for how much time and costs would be incurred at certain points in the various supply chains for carrying out certain specific IP procedures. The particular procedures that were queried upon were specifically those that are cost and time-sensitive to changing tolerance levels for GM content within non-GM wheat. The interview participants were also asked to estimate how much the time and costs would vary across five selected tolerance levels. The nature of the surveys, the interview participants and the sought after data are explained further in Chapter 4.

The interviewed participants were presented with basic supply chain models for which they were asked to estimate likely costs that would be incurred. Table 3-2 shows the nature of the farm and handling systems within which the estimates were made.

3.3 The Model

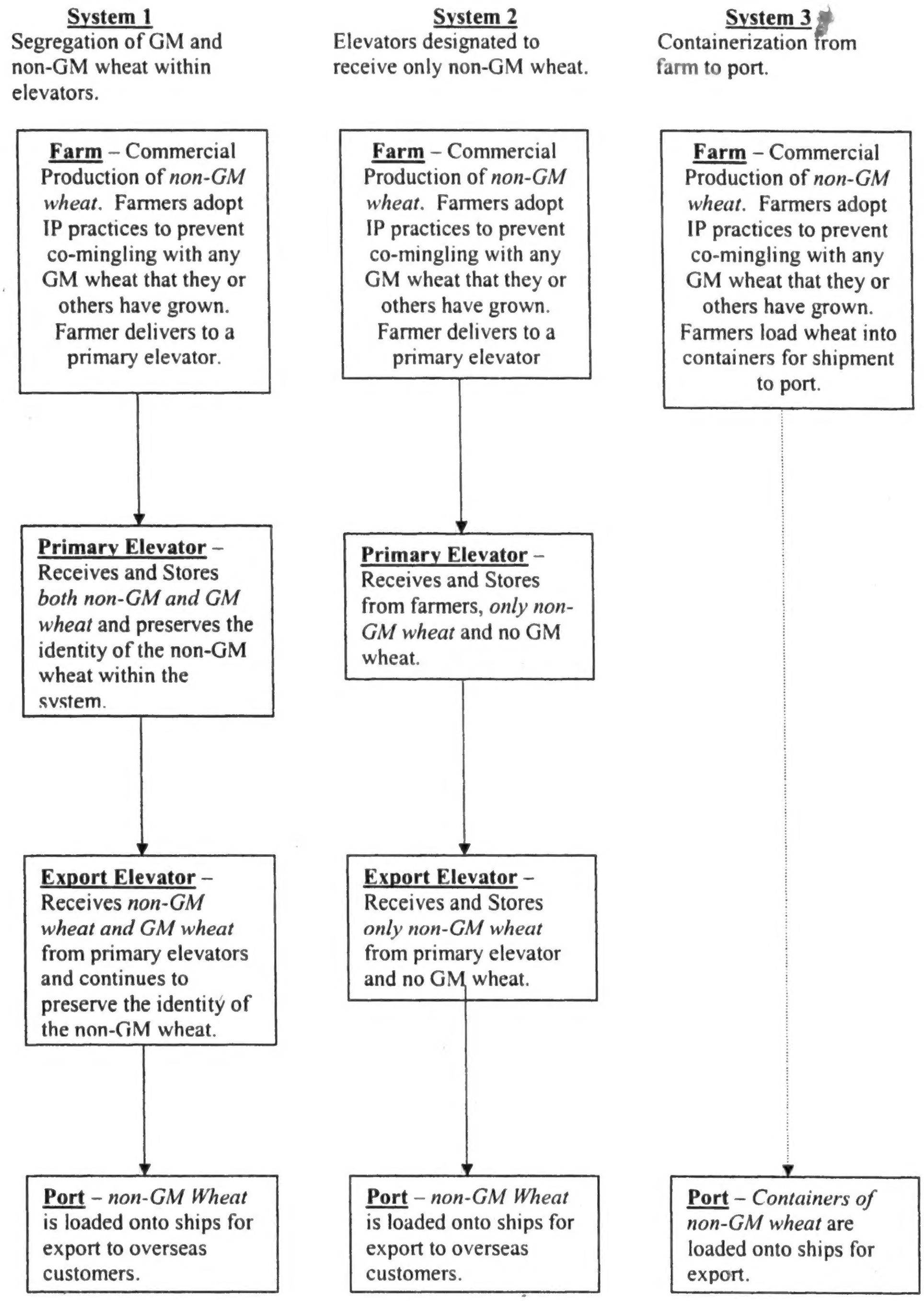
The study considers movement of non-GM wheat from the farmer to the export point through three alternate IP supply chain models. The model consists of three alternate supply chain systems, as depicted in Figure 3-1, which segregate and maintain the identity of non-GM wheat according to the threshold standard for non-GM wheat. The first segregation alternative involves the segregation and IP of non-GM wheat within elevator facilities that also handle GM wheat. The second option is based on designation of particular elevators as handling only non-GM wheat, and the third option involves containerization of non-GM wheat on farm with direct shipment to port, by-passing the elevator grain-handling system. The model isolates certain IP costs that are sensitive to different tolerance levels for GM content at each stage of the supply chains.

The interview participants from the various stages of the supply chain provided time and cost estimates within the given framework of the model for carrying out certain IP procedures. The participants provided estimates across five different tolerance levels. These estimates of time and costs were used to calculate the incremental IP costs for each stage within the three supply chain systems for non-GM wheat and across all five selected tolerance levels. The costs were added for each tolerance level within in supply system. The incremental cost estimates collected from the interview participants were tested to establish if different tolerance levels and different supply chain systems would have significant cost implications.

Sensitivity analyses were conducted to determine the how the costs would change according to a variation in certain factors such as the yield of the non-GM wheat crop and the wage in $/hour paid to the labourers performing the physical cleaning activities.

In addition to calculating the incremental IP costs for non-GM wheat and the analysis of those costs, aggregate cost totals were also calculated. Fixed IP costs (non-incremental) and other non-IP related costs of production, shipping and handling, gathered from previous research studies, were added to the incremental costs to provide a total aggregate cost calculation for each supply system across the five tolerance levels.

**Figure 3-1 Research Model: Three Alternate Supply Chain Systems
Non-GM IP Wheat, From Farm to Port**



System 1
Segregation of GM and non-GM wheat within elevators.

Farm – Commercial Production of *non-GM wheat*. Farmers adopt IP practices to prevent co-mingling with any GM wheat that they or others have grown. Farmer delivers to a primary elevator.

Primary Elevator – Receives and Stores *both non-GM and GM wheat* and preserves the identity of the non-GM wheat within the system.

Export Elevator – Receives *non-GM wheat and GM wheat* from primary elevators and continues to preserve the identity of the non-GM wheat.

Port – *non-GM Wheat* is loaded onto ships for export to overseas customers.

System 2
Elevators designated to receive only non-GM wheat.

Farm – Commercial Production of *non-GM wheat*. Farmers adopt IP practices to prevent co-mingling with any GM wheat that they or others have grown. Farmer delivers to a primary elevator

Primary Elevator – Receives and Stores from farmers, *only non-GM wheat* and no GM wheat.

Export Elevator – Receives and Stores *only non-GM wheat* from primary elevator and no GM wheat.

Port – *non-GM Wheat* is loaded onto ships for export to overseas customers.

System 3
Containerization from farm to port.

Farm – Commercial Production of *non-GM wheat*. Farmers adopt IP practices to prevent co-mingling with any GM wheat that they or others have grown. Farmers load wheat into containers for shipment to port.

Port – *Containers of non-GM wheat* are loaded onto ships for export.

3.4 Specific Assumptions

The primary assumption of the scenario that underlies this study is that transgenic varieties of Canadian Western Red Spring (CWRS) wheat, the primary class of Western Canada's export wheat, have been commercialized in Western Canada. Numbers of producers are assumed to have adopted this technology but there is assumed to be a continuing and appreciable export demand for non-GM CWRS wheat from Canada. This scenario provides the justification for developing IP systems to ensure that Canada can still supply export customers with non-GM CWRS wheat that meets the standards specified in purchase contracts. Standards such as those regarding tolerance levels for adventitious contamination by GM wheat beyond the tolerance level specified.

For the purposes of the study, it is assumed that approximately 50 percent of Western Canada's CWRS wheat is non-GM and contracted as such for export. This assumption reflects the experience of relatively rapid adoption of GM varieties of soybeans and canola. Assuming that appreciable quantities of both GM and non-GM grain are available simplifies the cost analysis considerably.

The agronomic benefits and costs for GM wheat will depend on the specific GM traits that a certain crop contains. Roundup Ready® wheat is currently the type of GM wheat that is closest to being commercially available. This wheat will be tolerant to the herbicide Roundup®. Among Canadian prairie farmers, the adoption rate for herbicide tolerant canola was more than 80 percent by 2002 (Mauro, Van Acker 2003, Grenier, 2003). Although it cannot be inferred that a prospective pattern of adoption for GM wheat would follow that of GM canola, the history of adoption of

GM canola is an indication that Western Canadian farmers will adopt GM crops if it is advantageous, economically or otherwise, for them to do so.

3.5 Tolerance Levels

The term "tolerance level" refers to a permissible deviation from zero, expressed as a percentage. From the perspective of the grain industry, "A tolerance for non-GM is referred to as the maximum allowable GM content to still be considered non-GM," (Wilson and Dahl, 2002). The term threshold is used in similar contexts to refer to the same acceptable level of GM content. The five tolerance levels that were chosen for analysis have been considered for use in various wheat importing countries. Specifically, these tolerance levels are: 5 percent, 3 percent, 1 percent, 0.5 percent and 0.1 percent. Table 3-1 provides a summary of the tolerance levels that are considered in this study, indicating a rationale for each selection.

Table 3-1 Specified Tolerance Levels and Rationale for Selection

Tolerance Level	Rationale
5%	Applied in several countries, i.e. Japan, Hong Kong.
3%	Anticipated threshold in South Korea, Thailand.
1%	Initial specification of EU labelling requirements.
0.5%	Current tolerance level for several non-GM IP programs for soybeans in Ontario.
0.1%	Scientifically feasible level for GM testing.

Sources: Philips and McNeil, 2000. Maltsberger and Kalaitzandonakes, 2000. Demeke, 2002.

3.6 Sub-Model Assumptions

Several sub-models underlie the three alternate supply chain models. In each case, certain assumptions are made to enable standardization of the cost estimates.

3.6.1 Farm Level Assumptions

The farm level component of the IP models is designed to be representative of grain producing farms in the Canadian prairies. The division of farmland in Western Canada involves sections composed of four 160 acre quarters (or quarter sections). A quarter section is tending to become a typical field size in Western Canada. The size of a reasonably representative commercial farm in the prairie region of Canada is about 2000 acres (Breitkreuz, 2002), which consists of twelve quarter sections, amounting to approximately 1920 workable acres. Based on these considerations, the farm model for this study is assumed to be a 2000-acre farm consisting of twelve quarter sections.

It is assumed that one full quarter section (160 acres) is dedicated, as one field, to non-GM IP wheat. This is a practical assumption, allowing the farmer to have a well-balanced rotation on other fields and the dedicated allotment is large enough in size to be practical.

Assumptions regarding the rotational or tillage practices of the farmer were not made in the model, nor imposed on the farmer interviewees, represented specifically by certified seed growers. It was assumed that each seed grower would give estimates according to the farm model presented to them, while considering his or her own practices of rotation and tillage. Therefore, the mean estimates for the seed growers include different assumptions concerning rotational and tillage practices. It was also assumed that the seed planted by farmers growing non-GM IP wheat was not contaminated with GM content[2].

The average yield for CWRS wheat in the Central Alberta region is approximately 50 bushels per acre (AAFRD, 2002-03a. Vyn, 2003). This is the assumed yield for the farm model. In addition, assumptions of the farm model which are imposed on the seed grower interviewees include a semi of 40 tonnes, a grain truck of about 14 tonnes to haul grain from the field to on-farm storage. In terms of the yield assumption of 50 bushels per acre, the total production for a quarter-section field is 217 tonnes, requiring an 8000-bushel bin. The farmer respondents were asked to provide time and cost estimates associated with segregation and cleaning of equipment. Typical combines, augers and bins are considered to be in use in the model farm of this study, as the differences between various types are negligible. Relative to time taken in cleaning equipment that was not characterized, such as seeders and dryers, respondents were asked to estimate cleaning time based on the characteristic features of their own equipment.

For the calculation of on-farm labour costs, an hourly wage of $15 per hour was used in the base case. This was based on the assumption that a hired labourer paid an average wage of $15 per hour would be most likely to do most of the cleaning activities (Vyn, 2003).

---

[2] There could be additional costs associated with testing to guarantee that seed is not contaminated with GM content. These costs, if any, are not estimated in the analysis, however, costs of purchasing certified seed are included.

3.6.2 Primary Elevator Assumptions

According to the Canada Grain Act, a primary elevator is simply an elevator that receives grain directly from farmers for the purpose of storing and/or shipping to other locations (CGC, 2003). Assuming that 50 percent of the CWRS grown in Western Canada is dedicated to non-GM IP wheat for export, different types of elevators would need to introduce different IP systems. Consequently, more than one type of elevator is considered in this study.

A high throughput elevator, or inland terminal, is one common type of primary elevator. They typically involve large concrete bin structures and are distinguished by their high level of efficiency seen in the fast rate at which they can receive and ship grain. Other primary elevators typically involve somewhat smaller steel bins; turnover time is somewhat slower than for the high throughput elevators. However, all of the study respondents indicated that the cost points of identity preservation that are sensitive to different tolerance levels are the same for the different types of elevators.

For the supply chain where non-GM and GM wheat are received at the same facility, and through the same pit and legs, a shipment restriction is necessary whereby the elevator only receives non-GM wheat at specific delivery times. This enables the elevator to be cleaned before receiving non-GM wheat in order to ensure that adventitious co-mingling is minimized. In contrast, the supply chain model that includes primary elevators receiving only non-GM wheat involves elevators in which an entire receiving pit, leg, storage and shipping system only handle non-GM wheat.

3.6.3 Export Elevator Assumptions

It is assumed that non-GM wheat is shipped from primary elevators to export terminal facilities where it is stored until it is loaded onto a ship for export. The model does not assume that a specific export terminal location will be used for non-GM wheat only. The export terminals through which Western Canadian grain is shipped are located in Vancouver and Prince Rupert in British Columbia, Churchill in Manitoba and Thunder Bay in Ontario.

Two different scenarios involving elevator systems are considered; one which involves the designation of an export elevator where a receiving pit, leg and storage area is dedicated as non-GM only, while the other assumes that both non-GM and GM wheat are received through the same system. As with the primary elevator system, the export facilities themselves are assumed not to differ in physical structure except for the possibility of some minor alterations to ensure that adventitious commingling is minimized.

3.6.4 Containerization Assumptions

Some assumptions concerning containerization are made for this form of identity preservation. Containers are assumed to hold 27 tonnes (60,000 lbs.) of wheat (Daoust, 2003), and are loaded on-farm. From the farm, they are sealed and shipped directly to the port by truck or rail, by-passing the system of grain handling elevators. It is assumed that the wheat is not bagged, but instead is loaded directly into the container. Standard food safety regulations require that containers are cleaned and sanitized regardless of the tolerance for GM material. Thus, cleaning of containers is considered not to be a factor in determining additional costs of IP for different tolerance levels. Table 3-2 depicts the model assumptions at the different stages of the supply chain.

Table 3-2 Nature of Supply Chain Elements Used for Cost Estimates

Supply Chain Stage	Assumptions
Farm	-Representative western Canadian farm used which is assumed to most likely grow non-GM IP wheat. -2000 acre farm. Non-GM IP wheat grown on a 160 acre field. -Average wheat yield 50 bushels per acre. -8000 bushel (220 tonne) bin used to store wheat. -40 tonne super B transport truck. -14 tonne (500bushel) farm grain truck. -$15 per hour wage for mechanical cleaning.
Primary Elevator	-Primary elevator is representative of western Canadian elevators. -$16 per hour wage for mechanical cleaning.
Export Elevator	-Model export elevator is representative of western Canadian export elevators. -$27.29 per hour wage for mechanical cleaning.
Containers	-Containers hold 27 tonnes of wheat. -Wheat is loaded directly into containers at the farm, without the use of a liner or bags. -Wheat is assumed to be in condition and placed in temporary storage on the farm before being loaded into containers.

Source: Alberta Agriculture and interviews with industry personnel.

CHAPTER 4

The Data

4.1 Introduction

The study focuses on development of estimates for incremental costs of particular components associated with identity preservation (IP) systems for non-genetically modified (non-GM) wheat as this passes through three alternate supply chains. The estimates of incremental costs are specifically for IP costs that are sensitive to and vary with alternative tolerance levels for GM content within grain shipments that are specified not to be genetically modified.

The data were collected following an initial overview of literature in a process that used three rounds of interviews. The purpose of the first round was to gather information to aid in the development of the questionnaires. The approach adopted was to interview key people in the wheat industry to determine which specific costs for IP are the most sensitive to different GM tolerance levels. A set of eight questionnaires was developed using the information from initial interviews with knowledgeable people in the grain industry (see Section 4.3 and Appendix A). Each questionnaire is focused on a specific segment of the wheat industry. The draft questionnaires were pre-tested by a selected group of industry representatives to ensure that the questions were pertinent and relevant. Finally the questionnaires were administered to members of the sample to gain their best estimates of the incremental labour hours and other related costs associated with different tolerance levels within the specified supply chains. These estimates provide a set of base data. Most of the questionnaires were completed with the aid of telephone or personal interviews in order to ensure clarity and consistency in the interpretation of the questions and the nature of the responses.

4.2 Data Specification

Following an overview of previous grain marketing literature and discussions with people knowledgeable of the wheat industry, it was concluded that data collection required two distinct steps:

1. Identification of the incremental IP costs that are sensitive to different tolerance levels for GM content. This was established through interviews with knowledgeable people within the industry.
2. Estimation of time and costs involved with IP practices at different stages within the supply chain for wheat. Interviews were conducted with individuals knowledgeable of IP practices within the grain industry. A number of people at each level of the supply chain were interviewed because of their familiarity with that specific stage or function.

Tolerance-sensitive cost points were identified at different stages of each of the three alternate supply chains. Farm level cost points are assumed to be identical for each of the three supply chain models since it is not until after the farm that the supply chains diverge. At the farm level, the activities of controlling GM crop volunteers, isolation zone practices and the mechanical cleaning of various pieces of equipment were identified to be tolerance level-sensitive cost points. In Systems 1 and 2 where the non-GM wheat moved through elevator systems, the tolerance-sensitive costs included mechanical cleaning of receiving, shipping and storage facilities (Figure 3-1). Additional costs in System 1 (in which an elevator handles both GM and non-GM grain) include certain capital expenditures that would limit adventitious co-mingling of non-GM and GM wheat, such as physical lockouts that would prevent the trickling of GM grain into a non-GM storage bin. In System 3 (Figure 3-1), which is the containerization scenario, no tolerance-sensitive cost points are identified after the farm level. However, testing for the presence of GM material is another tolerance-sensitive cost point at several stages of the supply chains in Systems 1 and 2. In System 3, GM testing is an issue only at the farm level. Figure 4-1 depicts each supply chain and its tolerance-sensitive cost points.

Figure 4-1 Cost Points Sensitive to Genetically Modified Content Tolerance Levels in Three Supply Chains

IP Cost Points		Non-GM & GM Within Elevator	Only non-GM In Elevator	Containerization of non-GM
Farm				
Isolation Zone		x	x	x
Volunteer Control		x	x	x
Cleaning	Seeder	x	x	x
	Combine	x	x	x
	Trucks	x	x	x
	Bin	x	x	x
	Dryer	x	x	x
	Auger	x	x	x
GM Test		x	x	x ↓
Primary Elevator				
GM Test		x	x	
Cleaning	Receiving	x	x	
	Shipping	x	x	
	Storage	x	x	
Capital Investment		x		
Export Elevator				
GM Test		x	x	
Cleaning	Receiving	x	x	
	Shipping	x	x	
	Storage	x	x	
Capital Investment		x		
Port				
Bulk		x ↓	x ↓	↓
Container				x ↓

Source: Initial interviews

4.3 Questionnaire Development and Application

A set of questionnaires was developed based on the tolerance-sensitive cost points identified in Figure 4-1. There were eight questionnaires in total, each for a specific group of industry respondents (see Appendix A).

Following approval of the questionnaires and the procedures outlined for these by the Human Ethics Review Board of the Faculty of Agriculture, Forestry and Home Economics at the University of Alberta, a pre-test of the each questionnaire was conducted. Each questionnaire was sent via e-mail or fax to a participant who had agreed to scrutinize the wording and structure of the questions to test that these were relevant and pertinent in attaining the goals of the study. The advice of the pretest respondents led to reorganizing and rewording of some questions in the final versions of the questionnaires.

Following ethics approval and pre-testing of the questionnaires, potential participants were identified, initially based on occupation and positions within the grain industry or academia. Those that were contacted and stated a proficiency in the subject area were asked if they were willing to participate in an interview pertaining to the questionnaire. If they responded positively, a copy of the questionnaire was faxed or e-mailed to them along with an information sheet. The questionnaire was followed up by a telephone interview/discussion to gather estimates from the participants.

There were eight groups (note that there were two distinct groups within the GM testing specialist group) of individuals from different stages in the supply chain who were asked to participate in an interview corresponding to the questionnaires:

1. **Plant Scientists & Agronomists** - Information regarding IP practices were gathered from five respondents within this group.
2. **Seed Growers** – From the membership list of the Alberta Seed Growers Association, a sample of thirty-five growers were randomly chosen from

the Central Alberta region. Fourteen seed growers responded and provided their best time and cost estimates for IP practices for producing non-GM wheat on their farm. It was decided that seed growers should represent farmers in general because of their knowledge and familiarity with IP procedures.

3. **Primary Elevator Operators** – Through word of mouth referrals, a sample of thirteen primary elevator operators was identified from the population of primary elevator operators in the region of Central Alberta by individuals knowledgeable of the grain industry. These individuals were approached and asked if they would be willing to provide their estimates of labour hours and costs incurred for IP procedures that they would perform under the scenario presented in this study. Seven individuals agreed to participate in an interview.
4. **Export Elevator Operators** – A sample of twelve operations managers from various export elevators in Canada was identified as potential candidates to provide IP cost and time estimates for their elevator. Three operations managers responded, offering their estimates for labour hours and costs incurred in association with IP activities at the export elevator level, under the scenarios presented in this study.
5. **Containerization Specialists** – Three individuals with knowledge of containerization of crops either through using containers in their own operation, or from their expertise in logistical/transport issues, were interviewed. These respondents provided estimates regarding costs

incurred for containerization, as well as other insights into the containerization industry.

6. **GM Testing Specialists** - This group consisted of twelve people from different areas of specialization dealing with GM testing in agriculture. Respondents included people from independent crop testing facilities, the Canadian Grain Commission as well as IP coordinators who handle current testing protocols for non-GM IP soybeans. Two questionnaires concerning GM-testing were administered to two different sub-groups of people. Six GM-testing specialists were interviewed and each was queried for cost estimates of the likely testing methods. Six IP coordinators were also interviewed who were familiar with existing GM-testing protocols for non-GM IP soybeans and other crops. The interviewees provided their best estimates for the GM-testing protocols that are likely to be implemented in each of the three alternate supply systems for non-GM IP wheat.

7. **Agricultural-Biotechnology Developers** (i.e. Monsanto) - Monsanto is the leading firm in developing GM wheat, specifically Roundup Ready® (RR) wheat, which is tolerant to the non-selective herbicide, Roundup®. Several people from Monsanto Inc. responded to questions concerning agricultural biotechnology for crops, specifically with regards to RR wheat.

Table 4-1 indicates the numbers of participants that were solicited to complete each questionnaire and the number of responses that were completed.

Table 4-1 Data Estimation: Survey Participants

Supply Chain Stage	Requests to Participate	Number of Respondents	Response Rate
Plant Scientists & Agronomists	8	5	63%
Farmers	35	14	40%
Primary Elevator	13	7	54%
Export Elevator	12	3	25%
GM Testing - Test Costs	7	6	86%
GM Testing - Protocols	9	6	67%
Container Specialists	5	3	60%
Biotechnology Developers	3	3	100%

4.4 Summary

The scope of the study is focused on the region of Central Alberta, which may or may not be representative of Western Canadian wheat farmers. The farm level costs are calculated based on the conditions prevailing in Central Alberta. Technology for subsequent levels of the supply chain systems is believed to be representative of Western Canadian conditions.

In summary, the cost points most sensitive to different tolerance levels in the three supply chains were identified. Estimates of the costs of IP for different tolerance levels were gathered using structured questionnaires and interviews with knowledgeable people including: plant scientists/agronomists, seed growers (representing commercial farmers), primary elevator managers, export elevator managers, grain testing specialists, IP co-ordinators, GM seed developers, regulators and others. From these cost assessments, the impact of specified tolerance levels on IP costs is estimated.

CHAPTER 5

Analysis and Discussion of Results

5.1 Introduction

As outlined in Chapter 4, interview respondents were requested to give their best estimates of incremental costs that would be incurred in the non-GM wheat identity preservation (IP) systems represented in the three alternate supply chain models (presented in Chapter 3), in the context of different tolerance level specifications. This chapter presents the estimates that were gathered. An analysis and discussion of these estimates is presented.

The cost analysis for each of the three supply chains is segmented into three stages of farm level, primary elevator and export elevator points. For each tolerance level, cost components at each of these stages are summed within each supply chain. Cost estimates are presented as costs per metric tonne of non-GM wheat. The cost figures represent the incremental costs that are estimated to exceed current cost levels, in the absence of identity preservation for non-GM wheat. Thus the current situation in which GM wheat has not been commercialized is the base case.

5.2 Farm Level Costs

At the farm level, according to the estimates of respondents, costs that are responsive to changes in tolerance levels include isolation zone costs, control of volunteer crops and cleaning of various pieces of farm equipment. These costs do not vary between the three supply chain systems, since it is not until after the farm-level stage that the supply chains diverge. Fourteen seed growers responded to the questions in the survey administered through interviews (see Appendix A1). Their best estimates of the hours of work and other cost components to achieve the specified tolerance levels are the basis of the data for this segment of the analysis.

5.2.1 Isolation Zones

Isolation zones act as a buffer between non-GM wheat fields and potential sources of contamination of GM wheat, either through pollen flow or from the spread of seed through the use of machinery. Fourteen seed growers provided estimates of the width of the isolation zone they would employ to achieve the specified tolerance levels. Of the fourteen respondents, two respondents estimated that isolation costs would be zero. One of these estimates was not used in the study[3], while the other was included in the calculations[4]. Each interviewee also specified the number of sides of the field that they would need to isolate for this purpose and each respondent indicated the soil cover practice that they would expect to apply to the isolation zone. Their responses were based on the questionnaire scenario for each tolerance level (outlined in Appendix A1). Based on the estimates given by thirteen seed growers, the average width of isolation zone and the number of sides that a field would typically require as isolation zones are each given in Table 5-1.

---

[3] One respondent held the viewpoint that an isolation zone would not be necessary under any tolerance level. This estimate was deemed not credible as this would likely result in the farmer not receiving an IP contract. Thus, this estimate for isolation zone costs was not used in the study. The rest of the responses from this individual however, were used.

[4] One respondent held that, in his operation, there were enough fields with adequate natural barriers that would enable him to avoid the need to incorporate unnatural isolation zones, thus avoiding the added costs. This observation was retained for analysis and included in the mean isolation zone costs.

Table 5-1 Average Estimated Isolation Zone Width and Number of Sides of Field Requiring Isolation		
	# of Sides of Field Requiring Isolation	*Isolation Zone Width (in metres)*
Tolerance Level	**Reported Average**	**Reported Average**
5%	0.31	0.62
3%	0.31	0.77
1%	1.00	2.19
0.5%	1.69	4.85
0.1%	2.38	8.23
Source: Estimates from thirteen seedgrowers.		

The average number of field sides that require isolation and the average width of the isolation zone that was reported may or may not be an accurate prediction of a future IP protocol for non-GM wheat. Nonetheless, this provides the best available basis for cost estimates. These data are, therefore, used to calculate the isolation zone component of mean farm-level costs across tolerance levels. Based on respondents' estimates, the means of the estimated costs of maintaining isolation zones are shown in Table 5-2. An analysis of the impact of different zone widths and the number of field sides for which isolation zones would be applicable is included later in this section.

Table 5-2 Mean Costs of Isolation Zones Across Tolerance Levels					
	Tolerance Level				
Cost of Isolation Zone	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
$ Per Tonne	$ 0.07	$ 0.07	**$ 0.18**	**$ 0.42**	**$ 0.72**
(standard error)	*(0.064)*	*(0.064)*	*(0.078)*	*(0.148)*	*(0.212)*
Costs in bold are significant at the 95% confidence interval. Source: Estimates from thirteen seed growers					

The means of the estimates of isolation zone costs increase as tolerance levels decrease, from $0.07 per tonne at the 5 percent tolerance level, to $0.72 per tonne at the 0.1 percent tolerance level. The results of a one-way ANOVA statistical test are reported in Table 5-10 at the end of this section. For this test, the null hypothesis is: there is no difference among the average costs of employing isolation zones (over the thirteen estimates) associated with different tolerance levels. The null hypothesis is rejected, as the F statistic of 5.60 is greater than the critical value of 2.51. Indeed then, there are statistically significant differences across tolerance levels for costs associated with utilizing isolation zones. A confidence interval test was used to determine if the mean costs were different from zero (see Table 5-11). The results indicate that the mean costs are significantly different from zero at the 1 percent, 0.5 percent and 0.1 percent tolerance levels but not at the 3 percent and 5 percent tolerance levels (see Table 5-11). As tolerance levels fall, there are increases in both the means and the variability of the isolation zone cost estimates. This supports the hypothesis that as tolerance levels are tightened, IP costs increase, due to the need for more stringent and costly practices that must be integrated into farmers' production operations.

One possible reason for the increase in standard error estimates as tolerance levels decrease is that the seed grower respondents are likely to be very familiar with the isolation zone practices that they would employ for the higher tolerance levels, since they use similar practices in their current seed growing operations (see Table 5-2). However, since the respondents have less experience with practices that would apply with much lower tolerance levels, it is not surprising that higher standard errors apply in these cases. Another possible reason for the increase in standard error of isolation cost estimates as tolerance levels become more stringent is that two different isolation zone practices were reported and included in the mean costs given in Table

5-2, and the variance between these two methods is higher at the lower tolerance levels. This is explored in the following section.

5.2.1.1 Isolation Zones: Comparing Two Potential Zone Practices

Currently, since no GM wheat is commercially produced in Canada, there is no incentive for identity preservation of non-GM wheat. Under situations where IP programs do exist, protocols apply to specified practices that must be followed in each part of the supply chain. For example, pedigreed seed growers adhere to the procedures and criteria laid out in the "Regulations and Procedures for Pedigreed Seed Crop Production" which is published by the Canadian Seed Growers' Association (CSGA) each year. Acceptable isolation zone practices for seed growers are outlined in that guide. In the case of wheat, the requirements include a 3 to 10 metre isolation strip around the entire crop, depending on what the neighbouring areas consist of (CSGA, circa.6-94). (There are currently no standards for non-GM wheat). Among the thirteen seed growers who provided information that is the basis of the non-GM wheat isolation zone estimates, two different practices were foreseen and reported as components for a potential protocol in non-GM IP wheat contracts. Seven seed grower respondents estimated isolation zone costs according to Method 1 (seeding isolation zone and harvesting separately), while five interviewees assumed that the Method 2 (leaving isolation zone bare) would be used (see Table 5-3). One respondent predicted that no isolation zone would be necessary on his farm due to the presence of natural barriers on enough of his fields. Although a situation where no isolation zone would be necessary at any tolerance level would not be standard, this situation could arise since some farmers own or rent enough land in a given area to be able to manage the crops in all adjoining fields. Forests, homesteads, highways or other types of natural or man-made barriers that could provide sufficient isolation from potential sources of GM contamination may naturally isolate other fields. For this reason, the respondent who predicted that no isolation zones would be necessary in his operation and thus did not cost this factor was included in the mean cost analysis. The analysis of the two different practices does not include this respondent.

Method 1, proposed by seven seed growers as their anticipated isolation zone practice, is a commonly used isolation zone practice by non-GM IP soybean growers in Ontario (Brown, 2003. Deweerd, 2003). This involves seeding the entire 160 acre field with non-GM wheat, harvesting the isolation zone separately from the rest of the field and selling that wheat separately from the non-GM wheat into a different market outlet (which would be lower priced than the IP wheat, since no non-GM premium would apply). The cost of operating this type of isolation zone practice consists of the price differential between the two crops (i.e. the premium on non-GM wheat) and additional time it may take to harvest separately and segregate the isolation zone crop. The premium is assumed to be $15 per tonne[5]. Although the loss of premium on the crop harvested from the isolation zone is not a direct cost, it is justified as a cost measure in this context since the non-GM premium reflects the additional costs incurred in the IP system. The farmer incurs these costs on the isolation zone, but does not recover these on the wheat produced in the isolation zone.

---

[5] Existing IP programs for wheat include premiums ranging from $10 per tonne (Reid, 2003) to $20 per tonne (Kennet, 1997).

The second type of isolation zone practice was proposed and costed by five respondents. This technique involves an isolation strip consisting of bare tilled ground. The costs associated with adopting this isolation zone protocol are estimated to be land rent, assumed to be $35 per acre (AAFRD, 2002) for the land taken out of production, plus cultivation of the isolation strips at $10 per acre (AAFRD, 2002). This $10 per acre is based on the most common custom rate in Central Alberta, representing total cultivation costs. An additional $50 flat fee for "time and trouble" is included as an additional cultivation cost component. A comparison of cost estimates for the two isolation zone practices is shown in Table 5-3.

Table 5-3 Mean Cost Comparisons for Two Different Isolation Zone Practices Across Tolerance Levels in $ per Tonne

		Tolerance Level				
Type of Isolation Zone	**Cost**	5%	3%	1%	0.5%	0.1%
Method 1	$ per field	$ 2.28	$ 3.43	$ 15.35	$ 29.10	$ 91.90
(same crop,	$ per tonne	$ 0.01	$ 0.02	**$ 0.07**	**$ 0.13**	**$ 0.42**
harvested separately)	*(standard error)*	*(0.01)*	*(0.016)*	*(0.026)*	*(0.035)*	*(0.136)*
Method 2	$ per field	$ 36.73	$ 36.73	$ 80.41	$ 197.30	$ 281.34
(tilled ground)	$ per tonne	$ 0.17	$ 0.17	$ 0.37	**$ 0.91**	**$ 1.29**
	(standard error)	*(0.169)*	*(0.169)*	*(0.177)*	*(0.269)*	*(0.415)*

Bold costs indicate significance at the 95% confidence level.

Source: Estimated costs by seven and five seed growers for Method 1and Method 2 repectively.

The standard errors of the cost estimates that are based on the responses from the seed growers increase as tolerance levels become stricter for both Method 1 (harvesting and marketing the isolation zone crop separately), and Method 2 (cultivating the isolation zone and leaving it bare). Similar to the estimates of isolation costs for the thirteen respondents, given in Table 5-2, estimated costs at the lower tolerance levels are significantly different from zero, while this is not the case for the isolation cost estimates for less stringent tolerance levels.

Based on the preceding assessments of two different methods of managing an isolation zone around a 160-acre non-GM IP wheat field, Method 1, which involves harvesting the isolation zone separately is the low-cost method. Faced with the choice of either of these isolation zone practices, commercial farmers would choose Method 1. However, the choice as to which type of isolation zone must be used, may not be made by the farmer. An IP contract for non-GM wheat may specify the particular method the farmer must adhere to.

5.2.1.2 Isolation Zone Protocol

Developing a protocol for isolation zone practices is a potential challenge for IP coordination. Such a protocol would be incorporated in the contractual agreement made with the farmer. Departing from the seed growers' estimates that were used to calculate the estimated mean costs of thirteen seed growers and the mean costs for each of two isolation zone methods in the previous sections, this section calculates the costs for each method based on possible protocols for width of isolation zones and the number of sides of the field that would be isolated that were identified after discussion with five agronomists about these issues. Table 5-4 indicates the number of acres of isolation zone for each combination of isolation zone widths and the number of sides of the field requiring an isolation strip. It should be noted that an isolation zone which is used on two sides of a field consists of two isolation strips which overlap on a corner of the field, that is, the strips are perpendicular to each other rather than being on opposite sides of the field.

Table 5-4 Area of Isolation Zone (acres) per 160 acre field

		# of Sides of the field Requiring Isolation			
	width(m)	*1 side*	*2 sides*	*3 sides*	*4 sides*
Width of Isolation Strips (metres)	*0.5*	0.10	0.20	0.30	0.40
	1	0.20	0.40	0.60	0.79
	3	0.60	1.19	1.79	2.38
	5	0.99	1.98	2.97	3.95
	10	1.99	3.95	5.92	7.85
	15	2.98	5.91	8.84	11.71
	20	3.98	7.85	11.73	15.51
	25	4.97	9.79	14.60	19.27
	30	5.96	11.71	17.45	22.97

Field is assumed to be square. Area of Isolation strip measured in acres.

The isolation zone area is an important component of the estimated costs for both isolation zone methods. For Method 1 (isolation zone consists of non-GM wheat that is separated and sold in the non-IP market), the size of the isolation zone (and the crop yield, assumed here to be 50 bushels per acre) determines the amount of wheat to be sold on the non-IP market. For Method 2 (where the isolation zone is tilled), the area in question also affects costs (land rent and cultivation). Table 5-5 shows cultivation cost calculations for a range of isolation zone sizes given in Table 5-4.

Table 5-5 Costs of Cultivating Isolation Zone

		# of Sides of the field Requiring Isolation			
		1 side	*2 sides*	*3 sides*	*4 sides*
Width of Isolation Strips (metres)	*0.5*	$ 50.99	$ 51.99	$ 52.98	$ 53.97
	1	$ 51.99	$ 53.97	$ 55.96	$ 57.94
	3	$ 55.96	$ 61.91	$ 67.85	$ 73.77
	5	$ 59.94	$ 69.82	$ 79.70	$ 89.52
	10	$ 69.88	$ 89.52	$ 109.15	$ 128.54
	15	$ 79.82	$ 109.09	$ 138.36	$ 167.07
	20	$ 89.77	$ 128.54	$ 167.32	$ 205.11
	25	$ 99.71	$ 147.87	$ 196.03	$ 242.65
	30	$ 109.65	$ 167.07	$ 224.50	$ 279.70

Calculations based on a $50 flat rate (interviews) + $10.00 per acre
Costs based on cultivating entire isolation zone.

Based on the possible parameters for isolation zones, and assuming a wheat yield of 50 bushels per acre and non-recovered costs due to a lost premium of $15 per tonne, in the context of the first of the isolation zone practices, the costs of isolation zone practice can be calculated on a per tonne basis, relative to the size of the zone. Similarly, costs associated with Method 2 (cultivating the isolation zone) can be calculated relative to the size of the isolation zone based on land rent of $35.00 per acre and the costs of cultivation.

Table 5-6 allows for comparison between the two methods of administering isolation zones for each tolerance level and for each combination of parameters specifying the width of zone and number of sides of the field for the zone. Isolation zone costs for Method 1 were calculated by multiplying the volume of wheat that would be harvested from each isolation zone, relative to the size of the zone, by the premium of $15 per tonne. For Method 2, isolation zone costs were calculated by summing the cost of cultivating each isolation zone, as given in Table 5-5, and the cost of renting the land that made up the isolation zone (at a rate of $35 per acre).

Table 5-6 Comparing Two Methods of Isolation Zone Management Under Different Parameter Specifications for Zone Width and Sides per Field Requiring Isolation
Total Cost of Isolation Zone per Field

Isolation Zone width(m)	# of Sides of the field Requiring Isolation							
	1 side		*2 sides*		*3 sides*		*4 sides*	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
0.5	$ 2.03	$ 54.47	$ 4.06	$ 58.94	$ 6.08	$ 63.41	$ 8.11	$ 67.87
1	$ 4.06	$ 58.95	$ 8.11	$ 67.88	$ 12.17	$ 76.82	$ 16.22	$ 85.74
3	$ 12.18	$ 76.84	$ 24.31	$ 103.58	$ 36.44	$ 130.33	$ 48.52	$ 156.97
5	$ 20.29	$ 94.74	$ 40.46	$ 139.20	$ 60.63	$ 183.65	$ 80.67	$ 227.83
10	$ 40.59	$ 139.47	$ 80.67	$ 227.83	$ 120.76	$ 316.20	$ 160.34	$ 403.44
15	$ 60.88	$ 184.21	$ 120.63	$ 315.92	$ 180.38	$ 447.62	$ 238.99	$ 576.83
20	$ 81.18	$ 228.95	$ 160.34	$ 403.44	$ 239.49	$ 577.94	$ 316.64	$ 747.99
25	$ 101.47	$ 273.68	$ 199.79	$ 490.42	$ 298.11	$ 707.15	$ 393.27	$ 916.93
30	$ 121.77	$ 318.42	$ 238.99	$ 576.83	$ 356.22	$ 835.24	$ 468.90	$ 1,083.65

Costs reported are in $ per 160 acre field and based on parameter assumptions for width of zone and for the number of sides of a 160 acre field that requires an isolation strip.

Method 1 involves planting zone with non-GM wheat, harvesting it separately and foregoing $15 premium per tonne.

Method 2 involves cultivating the isolation zone therefore incuring costs for cultivation and land rent.

Under specified parameters for the number of sides and width of isolation zones given in Table 5-3, comparison of Methods 1 and 2 again shows Method 1 to be the low-cost method in all instances (Table 5-6).

Based on the results presented above, if there is a choice to adopt either of the two isolation zone methods that are explored here, the farmer would choose Method 1 and grow non-GM wheat in the whole field, including the isolation zone, and harvest and market the wheat from the isolation zone separately. The premium would be forgone, but there would not be any other costs to be absorbed.

5.2.2 Volunteer Control Costs

Responding seed growers gave information about the costs they would incur in controlling volunteer Roundup Ready® (RR) wheat in their non-GM IP wheat fields.

The respondents provided estimates of the cost per acre for chemical control of volunteer wheat, based on their own rotational practices. Chemical control would take place either pre-seeding or pre-emergence of the present year's crop. The extra cost in controlling RR wheat volunteers arises since Roundup® or any other non-selective glyphosate herbicide will not kill RR wheat volunteers based on the GM-trait that makes the RR variety resistant to glyphosate. An additional chemical from a different herbicide group would have to be added to the tank mix, or sprayed at a different time, in order to kill RR wheat volunteers. The chemical control could not be done post-emergence of the crop since this would kill the non-GM wheat, along with any RR volunteers. According to the interviewed plant scientists, costs of chemical to control volunteer RR wheat could range from $5 to $16 per acre depending on the chemical needed for the specific rotation in question and how often the extra chemical would need to be applied. Some of the variation in the cost per acre in controlling volunteers would depend on the tillage practices of the farmer. A more extensive chemical program is necessary to control volunteers in no-till systems compared to conventional till systems. A summary of the seed grower responses to this question is in Table 5-7.

Table 5-7 Mean Incremental IP Costs of Volunteer Control

Cost of Controlling RR wheat Volunteers	**Tolerance Level**				
	5%	*3%*	*1%*	*0.5%*	*0.1%*
Reported Range	$0-16	$0-16	$0-16	$0-16	$0-16
$ Per Acre	$ 1.14	$ 1.14	$ 2.82	**$ 5.50**	**$ 6.64**
$ Per Tonne Produced	$ 0.84	$ 0.84	$ 2.09	**$ 4.15**	**$ 5.15**
(standard error)	*(1.143)*	*(1.143)*	*(1.309)*	*(1.283)*	*(1.384)*

Costs in bold are significant at the 95% confidence interval.

Source: Estimates from fourteen seed growers

The range of the costs of volunteer control, expressed per acre across all tolerance levels, that was reported by farmers was $0 to $16 per acre[6]. The average incremental cost estimate of $1.14 indicated for the 5 percent and 3 percent tolerance levels is not a realistic cost for a chemical treatment that would control RR wheat volunteers, reflecting the feature that only one respondent reported incremental costs for this activity at the 5 percent tolerance level, so the mean cost is low. The average cost estimate of $2.82 per acre, reported at the 1 percent tolerance level, is consistent with a practice that some farmers may follow to use chemical control to kill RR wheat every second year in which they grow non-GM IP wheat on a given field. Consequently, incremental chemical application costs could be spread over several years of producing non-GM wheat. Higher costs of $5.50 and $6.74 per acre at 0.5 percent and 0.1 percent tolerances, respectively, were estimated by the seed grower respondents, which is reflected in the costs per tonne of non-GM wheat produced of $4.15 and $5.15 for these tolerance levels.

From an ANOVA test to test for significant differences in this cost component across tolerance levels, an F statistic of 4.29 indicates significant differences across tolerance levels (see Table 5-10 for ANOVA results). Based on a confidence interval test, the cost estimates at the lower tolerance levels of 0.5 percent and 0.1 percent were the only ones that were statistically significantly different from zero (see Table 5-11). This is not unexpected; it was assumed that volunteer control costs would increase as the tolerance levels decrease, which suggests that change in tolerance levels is a significant component of cost.

---

[6] A study by Van Acker et. al. (2003) finds similar cost estimates. Van Acker et.al reason that non-GM wheat growers face additional chemical costs in minimum and no-till situations of $7.50 to $16.00 to control volunteer RR wheat, while farmers using conventional seeding have no extra chemical costs to control volunteer RR wheat in non-GM wheat.

5.2.3 Machinery Cleaning Costs

Machinery cleaning on farm involves the removal of crop residues from equipment and storage facilities used in the production, handling and storage of non-GM IP wheat. The fourteen interviewed seed growers responded to questions relating to cleaning in terms of the time they would need to spend cleaning various pieces of equipment used in their operation. Most of the costs of cleaning were calculated based on these time estimates with labour costed at $15 per hour. Flushing the combine included an extra cost of lost premium, which is explained later in this section. Costs per tonne produced were calculated based on a yield of 50 bushels per acre. The resulting cost estimates for the cleaning of equipment are given in Table 5-8.

Regarding the dryer that farmers would use to dry their wheat, it was estimated by two farmers in the Central Alberta region that they would need to dry their non-GM IP wheat approximately eight out of every ten years that they grew it. The dryer would be used and thus need to be cleaned 80 percent of the time, thus a factor of 0.8 was factored into the calculations for dryer cleaning costs.

The range of variations in reported time for cleaning items of machinery is quite large for some cleaning activities. Some of this variation may be attributable to variations in types and size of equipment; it also may be that some farmers tend to be more meticulous than others, even within a given protocol.

A series of ANOVA tests to test the significance of cleaning costs reported for the different tolerance levels reveals F statistics that are higher than the critical F value for all components except for combine flush costs, indicating that there are significant differences in on-farm cleaning activities for the different tolerance-levels, except for the costs associated with flushing the combine (Table 5-10). Results of confidence interval tests showed that all cleaning costs were significantly different from zero at the 95 percent confidence level, except for the cost estimates for seeder cleaning at the 5 percent and 3 percent tolerance levels (Table 5-11).

Seed growers estimated that they would spend additional time, ranging between 0 and 120 minutes, cleaning their seeder at the 5 percent tolerance level and from 10 to 240 minutes extra at the 0.1 percent tolerance level. There were some differences in the types of seeders used by the seed growers, but the reported cleaning practices were similar. The farmer would remove the remaining seed from the seed hopper, and vacuum it out if necessary. The seed hoses would be blown out, and any loose seed that might be lying on the machine would be swept off. The average of the reported cleaning times increased from 14 to 68 minutes as tolerance levels were tightened. Cleaning costs for the seeder increased from $0.02 to $0.08 per tonne as tolerance levels became more stringent.

Seed growers were asked which of three methods, (or which combination of methods) they would use in cleaning their combines. The methods were: a rigorous cleaning where practically "every kernel was removed from the machine", or a quick cleaning where the bulk of the remaining grain would be removed, while the third option involved a flush in which the farmer would harvest 30 bushels of the IP crop, and separate this from the rest of the crop in handling in order to market this as non-IP wheat. The costs of the first two cleaning methods involve only labour, while the third option of flushing include the extra time involved for this as well as the lost premium for the 30 bushels of wheat that would not be sold on the IP market.

All of the farmers reported cleaning their combines with a two step method that includes a quick clean and a flush. None of the fourteen seed growers interviewed reported that they would conduct a rigorous cleaning of the combine where practically every kernel would be removed. They said that this method would be impractical for them. The farmers reported that the flush requires some additional time and inconvenience to the farmer as he must combine some non-GM wheat and then dump this separately, just to ensure that the combine is as clean as possible before harvesting the IP wheat. These costs increased from $0.02 to $0.04 per tonne as the tolerance levels decreased over the ranges examined in this study.

Cost estimates for cleaning the combine before harvesting IP wheat averaged $0.03 per tonne at the 5 percent tolerance level and increased to $0.18 per tonne at the 0.1 percent tolerance level. A quick cleaning of the combine includes vacuuming out the combine's grain tank, opening up the bottom screens, emptying the rock trap and removing any obvious grain that is on any ledges on the outside of the combine. Reported "quick cleaning" practices varied across tolerance levels and tended to be more rigorous as the tolerance levels were reduced.

Several assumptions were spelled out to the surveyed seed growers regarding the size of trucks used to ship wheat, and the size of bin for storage. The respondents indicated that cleaning a 14 tonne grain truck would take an average of 6 minutes at the 5 percent tolerance level and 26 minutes at 0.1 percent, with the cost per tonne ranging from $0.01 to $0.03 per tonne from the 5 percent to 0.1 percent tolerance levels. Such trucks were viewed to be quite self-cleaning with little added effort required. A quick sweeping with a broom was reported as sufficient for the higher tolerance levels. For the lower tolerance levels, farmers reported that they would clean the outside of the truck and chassis and possibly go as far as to remove wheat from the tread of the tires. The practices for cleaning the tractor-trailer, also called a "semi", used for shipping wheat from the farm to the primary elevator were similar to those for smaller farm grain trucks. The average time to clean a "semi" was reported to increase from 6 minutes to 27 minutes as tolerance levels changed from the 5 percent tolerance level to the 0.1 percent level, giving incremental average costs of this activity of $0.01 and $0.03 per tonne for the 5 percent and 0.1 percent tolerance levels respectively.

It was assumed that on-farm storage bins would to be large enough to hold the entire non-GM IP wheat crop, which at 50 bushels per acre would require an 8000 bushel (220 tonne) bin. The additional time to clean the bin for IP wheat at the higher tolerance levels included sweeping out the bottom of the bin and sweeping down the walls of the bin. At the lower levels of tolerance, sweeping any nooks and crannies on the walls and floor would apply. The average cleaning time increased from 7 to 69 minutes as the tolerance level decreased, with incremental costs rising by $0.01 to $0.08 per tonne in these cases.

According to the interviewees, cleaning a dryer involves practices similar to those for cleaning a storage bin, but with more time needed due to more intricate components of the dryer. The average cleaning time increased from 24 minutes to 88 minutes, with a relative incremental IP cost increase from $0.02 at the 5 percent tolerance level to $0.08 per tonne at the 0.1 percent tolerance.

Farmers generally use an auger to move wheat, and this also needs to be considered for cleaning. Cleaning the auger was reported to be a relatively simple job. In general, augers have limited potential for harbouring grain. The inside of the auger tube and the flighting is usually shiny and slippery, leading grain naturally to slide off it. Seed growers stated that they would simply raise the auger and bang it with a rubber mallet to loosen any grain that might be inside the auger. The main task is to dump the auger boot, or vacuum crop residue out of it. The estimated average time for cleaning the auger increased from 4 minutes at 5 percent tolerance to 13 minutes at 0.1 percent tolerance. The mean costs for this operation were $0.00 per tonne at the 5 percent and 3 percent tolerance levels, $0.01 at the 1 percent and 0.5 percent levels and $0.02 at the 0.1 percent tolerance level.

The estimates of incremental mean costs for cleaning the various items of equipment, based on responses from the fourteen seed growers, are represented in Table 5-8. Included in the table is the range of time in minutes that was reported by the seed growers to clean each piece of equipment, as well as the average time estimate. Costs are calculated on a "per cleaning" basis, which simply gives the cost that it would take to clean each piece of equipment. The costs are also computed on a per tonne basis, as that is the unit measure that is being used for aggregate summation in this study.

Table 5-8 Estimated Costs of Cleaning Farm Equipmnet Across Tolerance Levels

		Tolerance Level				
Equipment	*Cleaning*	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Seeder	Range in Minutes	0-120	0-120	0-120	0-240	10-240
	Average Minutes	14	16	30	55	68
	Mean total cost	$ [illegible]39	$ 3.93	$ 7.50	$ 13.66	$ 16.88
	Mean $ per tonne	$ 0.02	$ 0.02	**$ 0.03**	**$ 0.06**	**$ 0.08**
	(standard error)	(0.010)	(0.010)	(0.011)	(0.019)	(0.020)
Combine	Range in Minutes	0-120	0-120	15-150	15-480	45-480
	Average Minutes	26	30	63	115	153
	Mean total cost	$ 6.54	$ 7.40	$ 15.87	$ 28.85	$ 38.37
	Mean $ per tonne	**$ 0.03**	**$ 0.03**	**$ 0.07**	**$ 0.14**	**$ 0.18**
	(standard error)	(0.010)	(0.010)	(0.012)	(0.037)	(0.036)
Truck	Range in Minutes	0-15	0-15	0-30	0-45	5-60
	Average Minutes	5	6	14	19	26
	Mean total cost	$ 1.34	$ 1.61	$ 3.39	$ 4.73	$ 6.52
	Mean $ per tonne	**$ 0.01**	**$ 0.01**	**$ 0.02**	**$ 0.02**	**$ 0.03**
	(standard error)	(0.002)	(0.002)	(0.003)	(0.004)	(0.005)
Semi	Range in Minutes	0-20	0-20	0-45	0-45	0-60
	Average Minutes	6	7	14	21	27
	Mean total cost	$ 1.61	$ 1.79	$ 3.39	$ 5.18	$ 6.70
	Mean $ per tonne	**$ 0.01**	**$ 0.01**	**$ 0.02**	**$ 0.02**	**$ 0.03**
	(standard error)	(0.002)	(0.002)	(0.004)	(0.005)	(0.007)
Storage Bin	Range in Minutes	0-30	0-30	0-60	0-120	0-180
	Average Minutes	7	8	25	46	69
	Mean total cost	$ 1.70	$ 1.96	$ 6.16	$ 11.52	$ 17.23
	Mean $ per tonne	**$ 0.01**	**$ 0.01**	**$ 0.03**	**$ 0.05**	**$ 0.08**
	(standard error)	(0.004)	(0.004)	(0.007)	(0.009)	(0.015)
Dryer	Range in Minutes	0-60	0-60	0-120	30-180	45-180
	Average Minutes	24	24	43	71	88
	Mean total cost	$ 5.97	$ 5.97	$ 10.69	$ 17.78	$ 22.08
	Mean $ per tonne	**$ 0.02**	**$ 0.02**	**$ 0.04**	**$ 0.07**	**$ 0.08**
	(standard error)	(0.003)	(0.003)	(0.007)	(0.009)	(0.009)
Auger	Range in Minutes	0-10	0-10	0-20	5-20	5-20
	Average Minutes	4	4	8	11	13
	Mean total cost	$ 1.07	$ 1.07	$ 2.05	$ 2.86	$ 3.21
	Mean $ per tonne	**$ 0.005**	**$ 0.005**	**$ 0.009**	**$ 0.013**	**$ 0.015**
	(standard error)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Combine Flush	Mean total cost	$ 6.62	$ 6.62	$ 11.31	$ 15.11	$ 16.07
	Mean $ per tonne	**$ 0.03**	**$ 0.03**	**$ 0.05**	**$ 0.07**	**$ 0.07**
	(standard error)	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)

Costs in bold are significant at 95% conficence interval.

Mean total costs are calculated over the production from the entire field.

Source: Estimates from fourteen seed growers

5.2.4 On-Farm Cumulative Tolerance-Sensitive IP Cost Estimates

The incremental IP costs for non-GM wheat that are sensitive to varying tolerance levels are summarized in Table 5-9. All mean costs are calculated per tonne of IP wheat produced, based on the estimates provided by the fourteen seed growers, except for isolation zones whose costs were calculated based on estimates from thirteen seed growers[7]. Other IP costs would be incurred at the farm level, but those would not vary if the tolerance level changed and thus are not considered here. They are, however, included in Section 5.8 in an analysis of aggregate costs.

Table 5-9 Tolerance Sensitive IP Cost Summary at the Farm Level
Estimated mean costs as tolerance varies ($ per tonne)

Farm IP Cost Points	**Tolerance Level**				
	5%	3%	1%	0.5%	0.1%
Isolation Zone	$ 0.07	$ 0.07	$ 0.18	$ 0.42	$ 0.72
Volunteer Control	$ 0.84	$ 0.84	$ 2.09	$ 4.15	$ 5.15
Cleaning Seeder	$ 0.02	$ 0.02	$ 0.03	$ 0.06	$ 0.08
Combine	$ 0.06	$ 0.06	$ 0.13	$ 0.21	$ 0.26
Truck	$ 0.01	$ 0.01	$ 0.02	$ 0.02	$ 0.03
Semi	$ 0.01	$ 0.01	$ 0.02	$ 0.02	$ 0.03
Bin	$ 0.01	$ 0.01	$ 0.03	$ 0.05	$ 0.08
Dryer	$ 0.01	$ 0.01	$ 0.02	$ 0.03	$ 0.04
Auger	$ 0.00	$ 0.00	$ 0.01	$ 0.01	$ 0.02
Combine Flush	$ 0.02	$ 0.02	$ 0.03	$ 0.04	$ 0.04
Tol-Sensitive Farm IP Costs	**$ 1.04**	**$ 1.06**	**$ 2.55**	**$ 5.03**	**$ 6.45**

Source: Estimates from fourteen seed growers.

Figure 5-1 portrays the information given in Table 5-9 in a stacked column bar graph. This indicates the continued increase in farm level incremental IP costs at lower tolerance levels for GM content. The total of these costs at the 5 percent and 3 percent tolerance levels, respectively, are $1.04 and $1.06 per tonne, indicating only a

1 percent cost increase from the 5 percent to 3 percent tolerance level. At the 1 percent tolerance level, the average of the incremental costs increases to $2.55. This represents a 144 percent increase from the 5 percent tolerance level. At the 0.5 percent tolerance level, the incremental average costs are $5.00 per tonne, which represents a 382 percent increase over the 5 percent tolerance level. At the 0.1 percent tolerance level, the incremental costs per tonne are $6.40, an increase of 517 percent above the comparable costs at the 5 percent tolerance for GM content.

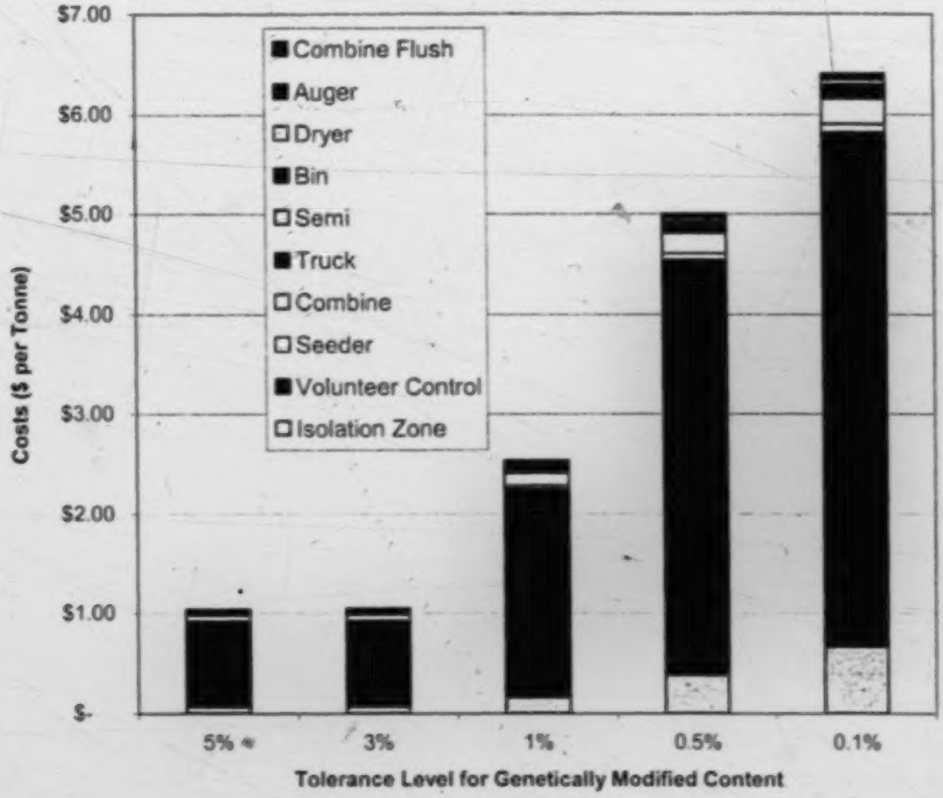


Figure 5-1 On-Farm Tolerance Sensitive Identity Preservation Costs

---

[7] One seed grower's response in regards to isolation zone costs was deemed not credible and therefore not used for the mean cost analyses. This seed grower's estimates for the other cost points however were used included in the analyses.

Table 5-10 provides results for the ANOVA tests that were performed on all the farm level IP costs of this section. Significance at the 95 percent level is shown in the table by bold values under the F statistic. Significance implies that there are statistically significant differences among the mean cost estimates across the different tolerance levels.

Table 5-10 Farm Level ANOVA Summary Statistics
Testing Mean Estimates for Significance Among Tolerance Levels

	ANOVA Statistics		
On-Farm Cost Point	*F*	*P-value*	*F crit*
Isolation Zone	**5.60**	**0.00**	2.51
Volunteer Crop Control	**4.29**	**0.00**	2.51
Cleaning Seeder	**3.89**	**0.01**	2.51
Combine	**7.16**	**0.00**	2.51
Truck	**7.84**	**0.00**	2.51
Semi	**5.61**	**0.00**	2.51
Bin	**13.13**	**0.00**	2.51
Dryer	**17.78**	**0.00**	2.51
Auger	**9.67**	**0.00**	2.51
Combine Flush	1.88	0.12	2.51

Bold F values and P-values indicate that there is significant differences among mean cost estimates at different tolerance levels for the specified cost point.

Table 5-11 gives results of the confidence interval tests conducted on the mean cost estimates that were calculated based on the responses of the fourteen seed growers for all of the farm level tolerance-sensitive IP costs.

Bold values in the table indicate that the mean cost estimates for the IP cost points are significantly different from zero at the 95 percent significance level.

Table 5-11 Farm Level Confidence Interval Summary Statistics
Testing Mean Estimates for Significant Difference from Zero

	Tolerance Level				
	5%	*3%*	*1%*	0.5%	0.1%
On-Farm Cost Point	*Lower Bound of Confidence Interval (significant if greater than zero)*				
Isolation Zone	-0.07	-0.07	**0.01**	**0.10**	**0.26**
Volunteer Crop Control	-0.97	-0.97	-0.01	**2.05**	**2.81**
Cleaning Seeder	-0.01	0.00	**0.01**	**0.02**	**0.04**
Combine	**0.01**	**0.01**	**0.05**	**0.06**	**0.10**
Truck	**0.00**	**0.00**	**0.01**	**0.01**	**0.02**
Semi	**0.00**	**0.00**	**0.01**	**0.01**	**0.02**
Bin	**0.00**	**0.00**	**0.01**	**0.03**	**0.05**
Dryer	**0.01**	**0.01**	**0.02**	**0.05**	**0.07**
Auger	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**
Combine Flush	**0.00**	**0.00**	**0.01**	**0.02**	**0.02**

Bold confidence interval statistics indicate that the mean cost estimates are significantly different from zero at the 95% significance level, for each specified IP cost point.

5.2.5 Sensitivity Analysis

In the preceding calculations, a number of standardized assumptions are made about farm-level operations including a yield of 50 bushels per acre, labour costs of $15.00 per hour, land rent costs of $35.00 per acre and an IP premium of $15.00 per tonne. In this section the effect of possible changes in these assumptions is assessed.

Premium for IP wheat programs that currently exist in Canada have been reported in a range of $10 per tonne to $20 per tonne (Reid, 2003. Deweerd, 2003.

Kennet, 1997) for certain varietal purity requirements. A base case non-GM premium of $15 per tonne was used in the model for this study, but if the premium was to differ, costs of the isolation zones as these were calculated for Method 1 would change. (Method 1 is where the isolation zone is seeded with IP wheat, but harvested separately). If the premium was to be higher than the base case of $15 per tonne, more premium would be foregone in selling the wheat harvested from the isolation zone in a non-IP market. Conversely, if the premium were to be less than in the base case, less premium would be foregone. Variation in the premium would also affect the additional combine costs for the non-recovered IP costs for the 30 bushel flush. Besides the base case premium of $15 per tonne for non-GM IP wheat, premiums of $10 and $20 per tonne are also analyzed as the range limits reported for current IP wheat programs. The variation in premium had minimal impact at the 5 percent, 3 percent and 1 percent tolerance levels. Only 3 cents more were forgone under the assumption of a $20 per tonne premium and 3 cents less under the assumption of a $10 per tonne premium at the 0.5 percent level. At the 0.1 percent tolerance level, however, a $10.00 premium decreased the tolerance-sensitive costs of IP at the farm level from $6.40 to $6.33 and a higher premium of $20.00 per tonne increased these particular costs from $6.40 to $6.46.

Land rent for the base case was assumed to be $35 per acre based on the most common reported land rent costs for the Central Alberta region (AAFRD, 2002). The reported range in land rent costs for the Central Alberta region ranged from $6.35 to $55 per acre (AAFRD, 2002). The effects of land rent only affect the cost of operating an isolation zone, and only for isolation zone Method 2, where the isolation zone consists of tilled ground. The rationale for land rent being used as a cost in this instance is that a farmer growing non-GM IP wheat on a rented field must still pay rent for the portion of the field that is cultivated as an isolation zone. Changing the land rent cost from the base case of $35 per acre to either extreme of the reported rental cost range ($6.83 and $55), the effect on the on-farm IP costs in question were minimal at both the 5 percent and 3 percent tolerance levels. Lowering the rate for land rent to $6.83 per acre lowered the total on-farm IP costs by less than $0.05 per tonne for the 1 percent tolerance level and by $0.11 per tonne at the 0.5 percent tolerance level. Raising the rental rate to $55 raised total on-farm IP costs by less than $0.05 per tonne at the 1 percent tolerance level, and by $0.11 per tonne at the 0.5 percent tolerance level. At the 0.1 percent tolerance level, land rent costs of $6.83 per acre lowered the farm-level tolerance-sensitive IP costs from $6.40 to $6.16 per tonne, a difference of $0.24 per tonne, and at the higher rental cost of $55 per acre, the tolerance-sensitive IP costs were $6.57, up from $6.40 per tonne, a total of $0.17 per tonne higher than at the base case rent cost. Table 5-12 displays the variations in land rental rates from $6.83 per acre to $55 per acre and their effect on incremental farm IP costs[8].

For the calculation of on-farm labour costs, an hourly wage of $15 per hour was used in the base case. This was based on the assumption that a hired labourer paid an average wage of $15 per hour would be most likely to do most of the cleaning activities. For the purpose of sensitivity analysis, we considered that some farm labour could be hired at $12 an hour, and that in some cases, the cleaning could be done by a farm manager or owner, whose time could be costed at $20 per hour. Variations in labour costs minimally affect the mechanical cleaning portion of IP costs. At $12 per hour, incremental IP costs at the farm level are decreased from the base case of $6.40 by $0.02 per tonne at the 5 percent and 3 percent tolerance levels, by $0.04 at the 1 percent tolerance level, by $0.08 at the 0.5 percent tolerance level. At the 0.1 percent tolerance level, incremental IP costs at the farm-level decreased from $6.40 to $6.29 ($-0.11). When labour is costed at $20 per hour, farm-level tolerance-sensitive IP costs would increase from the base case of $6.40 per tonne by $0.05, $0.06, $0.12, $0.21 and $0.28 for the tolerance levels of 5 percent, 3 percent, 1 percent, 0.5 percent and 0.1 percent respectively (Table 5-12).

---

[8] The variation of land rent between $6.83 and $55 per acre is based on data for the Central Alberta region (AAFRD, 2002). It is likely that land that is available at the lower rental prices would not be used for IP wheat since this cheaper land is most likely lower in quality and likely to no be productive enough to justify growing IP crops and warrant the additional costs of identity preservation.

In contrast to variations in IP premiums, land rental rates and wages for farm labour, yield variations have pronounced effects on IP costs per tonne. Given the use of standard farm practices, yield remains difficult to predict, primarily due to variations in weather. In a low-yield year, the IP costs that are considered in this analysis will still apply and be similar to those that apply in a year with an excellent yield. However, the costs per tonne are affected. A 50-bushel base yield was assumed since this is the approximate average CWRS wheat yield reported for the Central Alberta area for the four year period of 1998-2001 (AAFRD, 2002-03a. Vyn, 2003). The average wheat yield for Alberta as a whole is slightly less than 40 bushels per acre, over the same period. Thus, a yield of 40 bushels per acre is also considered in the sensitivity analysis. A low-end yield of 30 bushels was also considered in order to represent yield under less than ideal conditions of temperature or moisture.

Yields of 60 and 70 bushels per acre are also considered as the upper-end possibilities for the Central Alberta region. According to the analysis, yield changes had a very substantial effect on IP costs per tonne at the farm level. From the base case of 50 bushels an acre and $1.03 for incremental IP costs at the 5 percent tolerance level, a drop in yield to 30 bushels per acre increased the incremental IP costs by $0.66 per tonne (64.43 percent) and a yield of 70 bushels decreased the incremental IP costs by $0.28 (27.61 percent) per tonne. At the 0.1 percent tolerance level, a yield of 30 bushels per acre increased incremental IP costs by $4.08 per tonne from $6.40 to $10.48 (63.82 percent) while a yield of 70 bushels per acre decreased incremental farm IP costs to $4.65 per tonne, a difference of $1.95 (27.35 percent).

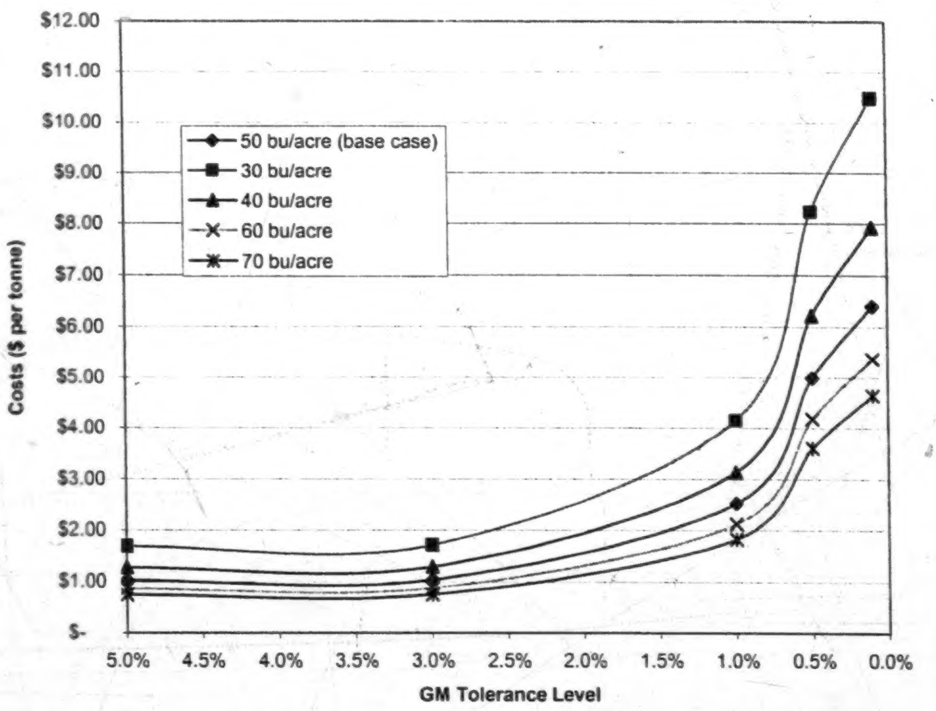
The effect of yield variations on the estimated incremental IP costs of various threshold levels is shown in Figure 5-2 for different yield situations across the five tolerance levels. Table 5-12 shows the differences in farm-level incremental IP costs for yield variations as well for the assumed variations in premium, land rent and labour cost. The percentage difference, for farm-level incremental IP costs, is also given for each variation in premium, land rent, labour cost and yield from the base case scenario.

Table 5-12 Sensitivity Analysis for Farm IP Costs

	Tolerance Level				
	5%	3%	1%	0.5%	0.1%
Variable	Cost per Tonne				
Premium ($ per tonne)					
$15.00	**$ 1.03**	**$ 1.04**	**$ 2.52**	**$ 4.99**	**$ 6.40**
$10.00	$ 1.03	$ 1.04	$ 2.52	$ 4.97	$ 6.33
Change From Base Case	-0.13%	-0.21%	-0.35%	-0.36%	-1.04%
$20.00	$ 1.03	$ 1.04	$ 2.53	$ 5.01	$ 6.46
Change From Base Case	0.13%	0.21%	0.35%	0.36%	1.04%
Land Rent ($ per acre)					
$35.00	**$ 1.03**	**$ 1.04**	**$ 2.52**	**$ 4.99**	**$ 6.40**
$6.83	$ 1.00	$ 1.01	$ 2.47	$ 4.84	$ 6.16
Change From Base Case	-2.67%	-2.63%	-1.99%	-3.03%	-3.71%
$55.00	$ 1.05	$ 1.06	$ 2.56	$ 5.10	$ 6.57
Change From Base Case	1.89%	1.87%	1.42%	2.15%	2.64%
Labour($ per hour)					
$15.00	**$ 1.03**	**$ 1.04**	**$ 2.52**	**$ 4.99**	**$ 6.40**
$12.00	$ 1.01	$ 1.02	$ 2.48	$ 4.91	$ 6.29
Change From Base Case	-1.85%	-2.01%	-1.78%	-1.56%	-1.61%
$20.00	$ 1.06	$ 1.08	$ 2.60	$ 5.12	$ 6.57
Change From Base Case	3.08%	3.36%	2.97%	2.61%	2.69%
Yield (bushels per acre)					
50 bushels	**$ 1.03**	**$ 1.04**	**$ 2.52**	**$ 4.99**	**$ 6.40**
30 bushels	$ 1.69	$ 1.71	$ 4.15	$ 8.24	$ 10.48
Change From Base Case	64.43%	64.29%	64.59%	65.01%	63.82%
40 bushels	$ 1.28	$ 1.29	$ 3.14	$ 6.21	$ 7.93
Change From Base Case	24.16%	24.11%	24.22%	24.38%	23.93%
60 bushels	$ 0.86	$ 0.87	$ 2.12	$ 4.18	$ 5.38
Change From Base Case	-16.11%	-16.07%	-16.15%	-16.25%	-15.96%
70 bushels	$ 0.75	$ 0.76	$ 1.83	$ 3.60	$ 4.65
Change From Base Case	-27.61%	-27.55%	-27.68%	-27.86%	-27.35%

Bold costs are based on base case assumptions.

Figure 5-2 Sensitivity of Farm IP Costs to Yield Variations



5.3 GM Testing

GM testing will be necessary within any supply chain for non-GM IP wheat. This section focuses on the cost of GM testing for the three alternate IP systems that are considered in this study. Since GM wheat is not licensed for commercial production at this time, no GM tests are currently specifically indicated for wheat. Furthermore, there is no defined protocol as to when, where and how often non-GM shipments must be tested. Six GM testing specialists responded to questions in the survey that deal specifically with GM testing costs (see Appendix A3). Additionally, six IP coordinators who are familiar with GM testing methods and procedures for other crops responded to survey questions that asked for an outline of components of a possible protocol for GM testing within each of the alternate supply systems (see Appendix A4). The surveyed IP coordinators are familiar with such current non-GM IP programs as for soybeans in Ontario and/or those IP programs that currently apply in the wheat industry in Western Canada. Potential protocols for testing non-GM wheat were developed from these interviews and subsequently verified with the group so that unique features of a system for non-GM wheat would not be overlooked.

For the purposes of this study, testing for the presence of GM wheat within non-GM IP wheat consignments is assumed to involve testing for one GM trait only, the Roundup Ready® (RR) trait. This is similar to the testing currently being used in non-GM soybeans, for which there is also only one GM trait currently commercialized, again, the RR trait. According to the surveyed respondents, it is likely that the tests for non-GM wheat will include strip tests, ELISA tests and PCR tests, which are currently being used in GM testing for soybeans (see Chapter 2). Mean cost estimates for each of these are given in Table 5-13, based on information given by the surveyed respondents. These estimates are used to calculate costs of GM testing in the context of the protocols designed from interviews with IP coordinators for the three supply chains and across tolerance levels.

Table 5-13 Mean Incremental IP Costs of GM-Tests for Wheat

Test Type	Cost per Test
PCR	$ 310.83
(standard error)	(24.6785)
ELISA	$ 35.00
(standard error)	(1.5055)
Strip Test	$ 6.92
(standard error)	(1.1791)

Source: Estimates from six GM-Testing Specialists

Table 5-14, Table 5-15 and Table 5-16 show the potential GM-testing protocols for Supply Systems 1, 2 and 3 respectively, based on interviews with IP coordinators. These resemble typical testing protocols for non-GM IP soybeans in Ontario, but reflect the characteristics of the identified supply chains for Western Canadian wheat. Based on initial interviews, it was assumed that grain trucks delivering from the farm to the primary elevators, hold on average 25 tonnes (semis 40 tonnes, grain trucks 14 tonnes), while rail hopper-cars transporting wheat from primary elevators to export elevators carry 90 tonnes of wheat and containers hold 40 tonnes. These assumptions are applied in order to calculate GM-testing costs per tonne.

Table 5-14 Plausible GM-Testing Protocol and Costs Across Tolerance Levels

System 1: Elevators Receive Both non-GM and GM Wheat

Primary Elevator Level

Tolerance Level	***Testing Frequency***	***Per # of Tonnes***	***Cost $/Tonne***
Receiving	*(loads = 25 tonne average truck)*		
5%	1 Strip, first load into elevator	218	$ 0.03
3%	1 Strip, first and every 10th load	218	$ 0.03
1%	1 Strip, first and every 5th load	125	$ 0.06
0.5%	1 Strip every 2nd load	50	$ 0.14
0.1%	1 Strip every load	25	$ 0.28
Shipping	*(rail car = 90 tonnes)*		
5%	1 Strip every 5th rail car	450	$ 0.02
3%	1 Strip every 5th rail car	450	$ 0.02
1%	1 ELISA every 5th rail car	450	$ 0.08
0.5%	1 ELISA every 2nd rail car	180	$ 0.19
0.1%	1 ELISA every rail car	90	$ 0.39

Export Elevator

Tolerance Level	***Testing Frequency***	***Per # of Tonnes***	***Cost $/Tonne***
Receiving	*(rail car = 90 tonnes)*		
5%	1 Strip every car	90	$ 0.08
3%	1 Strip every car	90	$ 0.08
1%	1 Strip every car	90	$ 0.08
0.5%	1 Strip every car	90	$ 0.08
0.1%	1 Strip every car	90	$ 0.08
Shipping	*(on ship)*		
5%	1 PCR	25000	$ 0.01
3%	1 PCR	15000	$ 0.02
1%	1 PCR	10000	$ 0.03
0.5%	1 PCR	5000	$ 0.06
0.1%	1 PCR	1500	$ 0.21

Source: Interviews with six IP coordinators and six GM-testing Specialists

Table 5-15 Plausible GM-Testing Protocol and Costs Across Tolerance Levels

System 2: Elevators Receive Only non-GM Wheat

	Primary Elevator		
Tolerance Level	***Testing Frequency***	***Per # of Tonnes***	***Cost $/Tonne***
Receiving	*(loads = 25 tonne average truck)*		
5%	1 Strip, first load into elevator	218	$ 0.03
3%	1 Strip, first and every 10th load	218	$ 0.03
1%	1 Strip, first and every 5th load	125	$ 0.06
0.5%	1 Strip every 2nd load	50	$ 0.14
0.1%	1 Strip every load	25	$ 0.28
Shipping	*(rail car = 90 tonnes)*		
5%	none	*n/a*	$ -
3%	none	*n/a*	$ -
1%	none	*n/a*	$ -
0.5%	none	*n/a*	$ -
0.1%	none	*n/a*	$ -
	Export Elevator		
Tolerance Level	***Testing Frequency***	***Per # of Tonnes***	***Cost $/Tonne***
Receiving	*(rail car = 90 tonnes)*		
5%	1 Strip every rail car	90	$ 0.08
3%	1 Strip every rail car	90	$ 0.08
1%	1 Strip every rail car	90	$ 0.08
0.5%	1 Strip every rail car	90	$ 0.08
0.1%	1 Strip every rail car	90	$ 0.08
Shipping	*(on ship)*		
5%	1 PCR	25000	$ 0.01
3%	1 PCR	15000	$ 0.02
1%	1 PCR	10000	$ 0.03
0.5%	1 PCR	5000	$ 0.06
0.1%	1 PCR	1500	$ 0.21

Source: Interviews with six IP coordinators and six GM-testing Specialists

Based on the protocol developed for GM testing, strip tests would be used when non-GM wheat is received at the primary elevator level. The number of tests required varies across tolerance levels. For Supply Systems 1 and 2, the protocol and therefore the costs, would be identical at this stage. At 5 percent tolerance, 1 strip test is necessary when the farmer brings in the first load of non-GM wheat. The estimated cost for a strip test at this point is $0.03 per tonne. As long as the test result is acceptable, no further testing is required. At the 0.1 percent tolerance level, 1 strip test is required for every load of incoming grain at a cost of $0.28 per tonne for this component of non-GM IP costs. The time required for a test strip to be completed is about five minutes, which is not an important issue when considering the value of time as incoming deliveries typically have to wait at least that long before they are given clearance to unload, irrespective of any GM testing.

Testing of outgoing IP wheat from the primary elevator differs between System 1, which involves elevators that segregate non-GM and GM wheat within the same facility, and System 2, involving designated non-GM elevators. In System 1, strip testing is required at the 5 percent and 3 percent tolerance levels, while a more sophisticated ELISA test is required at the 1 percent, 0.5 percent and 0.1 percent tolerance levels. For System 2, the interviewed experts held that no testing would be necessary on the out-going IP wheat, since the wheat had been tested at receiving, and given that no GM wheat is received at a designated non-GM facility, there should not be a concern of adventitious contamination within the primary elevator. ELISA tests take considerable time to conduct, approximately six hours. However, the sample can be taken and tested before the rail car has traveled from the western prairies to port. Thus, a rail car with questionable GM content level can be identified and re-screened if necessary, and be removed from the IP system before being unloaded at the export terminal if needed. This would prevent contamination of a much larger consignment.

At the export elevator level, System 1 and System 2 have identical protocols and subsequently, identical GM testing costs. The protocols are also identical for each tolerance level. Each 90 tonne rail car would be strip tested (at a cost of $0.08 per tonne) before being unloaded at the export elevator. The Canadian Grain Commission (CGC) samples out-going wheat during ship loading. The sample is then subject to a PCR test. This is currently the standard test for non-GM soybeans and other non-GM IP products that are designated for export. The mean cost of a PCR test is shown in Table 5-13 as $310.83 and depending on the frequency of the testing, the cost per tonne would vary across tolerance levels. In the context of this study, based on estimates of knowledgeable people in the industry, testing at the port would cost between $0.01 per tonne at the 5 percent tolerance level and $0.21 per tonne at 0.1 percent. This is calculated assuming one PCR test per 25000 tonnes and 1500 tonnes respectively. According to an export elevator operations manager interviewed during the course of the study, 25000 tonnes is a typical size of export shipment of wheat and therefore would be the typical frequency for PCR-testing at the 5 percent tolerance level where only one test is needed for the whole shipment. An interviewed CGC employee quoted that 1500 tonnes was the likely default frequency for very low tolerance levels, and that therefore it would be likely that a PCR test would be used for every 1500 tonnes at 0.1 percent tolerance.

System 3 involves the on-farm containerization of wheat. Wheat is loaded directly into a container, sampled for testing and then sealed until it reaches its destination. Table 5-16 shows the protocol, developed through interviews, and the costs per tonne calculated for GM testing in a containerization system.

Table 5-16 Plausible GM-Testing Protocol and Costs Across Tolerance Levels			
System 3: Containerization			
On-Farm			
Tolerance Level	***Testing Frequency*** *(Container holds 20 tonnes)*	***Per # of Tonnes***	***Cost $/Tonne***
5%	1 PCR per farm (11 containers)	218	$ 1.43
3%	1 PCR per farm (11 containers)	218	$ 1.43
1%	1 PCR per farm (11 containers)	218	$ 1.43
0.5%	1 PCR per farm (11 containers)	218	$ 1.43
0.1%	1 PCR per farm (11 containers)	218	$ 1.43

Source: Interviews with six IP coordinators and six GM-testing Specialists

It was reported that only one PCR test would be necessary for any tolerance level in the containerization system. Representative samples would be taken at the farm from each container in the proper sampling manner, mixed and tested with one PCR test. The PCR test would take 4-6 days to complete, and if the test showed that the level of GM content was too high, then the containers could be intercepted, before they were loaded onto a ship at port, for further screening. The cost of one PCR test for the entire container shipment from one farmer would be $1.43 per tonne.

5.4 Primary Elevator Level Costs

According to preliminary interviews with primary elevator operators, tolerance-sensitive costs that a primary elevator would typically incur for a non-GM IP program include testing for GM content, cleaning of various forms of equipment and capital expenditure for devices to aid in the prevention of co-mingling of non-GM and GM wheat. These devices consist of physical and electronic lockout systems. According to our approach of three alternate supply systems, after the farm, there are two systems within which the non-GM IP wheat is delivered to a primary elevator.

System 1 involves a primary elevator that receives both non-GM and GM wheat into the same structure; and the second system involves a primary elevator that receives no GM wheat and is designated for non-GM receipts only.

Seven primary elevator operators responded to the questions in this component of the survey administered through interviews (see Appendix A2). Their best estimates of the labour-hours required for cleaning, and the additional cost of capital within their primary elevators, under both System 1 and System 2 scenarios, were used as the foundation for the data for this section. Two additional sets of interviews were used to gather estimates that dealt specifically with GM testing, which occur at the primary elevator level and elsewhere. One of these interview sets was directed at GM testing specialists who were able to provide cost estimates for the various GM tests that are likely to be used for GM wheat, and the other interview set was directed to individuals who were familiar with existing non-GM testing protocol for soybeans and were able to provide estimates regarding possible protocol with specific regards to non-GM IP wheat. All incremental IP costs at the primary elevator level are calculated on a per 1000 tonne basis initially, and modified to a per tonne value to be consistent with the rest of the IP cost estimates and calculations from other points in the supply chain.

The cost estimates for GM testing at the primary elevator, and other stages of the supply chain, were calculated separately from the rest of the costs at the primary elevator. Testing cost estimates were provided from a different group of interviewees than the estimates provided by the primary elevator operators. GM testing cost estimates are given in Section 5.3.

5.4.1 Mechanical Cleaning Costs

Mechanical cleaning costs at the primary elevator level involve the removal of crop residues from the grain handling and storage structures and equipment within the elevator facility. This cleaning consists largely of manual labour, sweeping and removing any grain that may be left over in the various parts of the elevator system.

The components of the facility that need to be considered for cleaning include the receiving pit and leg, storage bins and the shipping leg. The incremental costs for cleaning these were calculated based on the estimated time required for the cleaning activity and using a labour cost of $16 per hour, the reported wage for typical personnel that would be involved in cleaning activities. These cost estimates are based on reports of how often the cleaning activity would be necessary, depending on conditions that the various elevator managers foresaw for the non-GM IP program. Under the assumption of System 1, where the elevator would receive both non-GM and GM wheat, respondents anticipated that they would only receive non-GM IP wheat at certain specified times. In anticipation of this, they would clean the system and then receive only non-GM wheat for a specified time period, or until a certain amount of non-GM wheat was received.

The responding elevator managers provided estimates based on both supply systems, one where they would receive both GM and non-GM wheat and the other where they would only receive non-GM wheat. The mean cost estimates for System 1 are presented in Table 5-17, based on costs per 1000 tonnes.

Table 5-17 Mean Incremental IP Costs of Mechanical Cleaning at the Primary Elevator
System 1: non-GM and GM wheat received within the same elevator

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/1000 tonnes	$ 4.07	**$ 5.11**	**$ 7.83**	**$ 18.15**	**$ 21.84**
	(standard error)	(1.749)	(1.551)	(2.487)	(5.548)	(6.080)
Clean Storage	$/1000 tonnes	$ 5.04	$ 5.31	$ 10.02	$ 20.16	$ 21.14
	(standard error)	(2.730)	(2.675)	(4.634)	(8.926)	(8.664)
Clean Shipping	$/1000 tonnes	$ 1.65	$ 2.15	$ 4.70	**$ 7.76**	**$ 8.59**
	(standard error)	(0.847)	(0.989)	(2.100)	(2.069)	(1.889)
Total Cleaning Costs ($/1000 tonnes)		$ 10.77	$ 12.57	$ 22.55	$ 46.08	$ 51.56

Costs in bold are significantly different from zero at the 95% significance level.

Source: Estimates from seven primary elevator operators

For the data relating to System 1, a series of ANOVA tests for significance among cleaning costs reported for the different tolerance levels reveals F statistics that are higher than the critical F value, for mechanical cleaning of the receiving pit and legs, the shipping legs and capital expenditure but not for cleaning the storage bins (see ANOVA results, Table 5-20). Significant F statistics imply that there were significant differences among the costs among the different tolerance levels for the specified cleaning activities. Confidence interval testing revealed that for System 1, the costs of cleaning the receiving portion of the primary elevator were significantly different from zero at the 95 percent confidence interval at all tolerance levels considered except for the highest tolerance level, 5 percent. The mean of the incremental cost estimates for elevator cleaning for System 1 increased from $4.07 per 1000 tonnes at the 5 percent tolerance level to $21.84 per 1000 tonnes at the 0.1 percent level. The mean cost estimates for cleaning storage bins increased from $5.04 to $21.14 per 1000 tonnes between the 5 percent and the 0.1 percent-tolerance levels. According to the ANOVA test, there was no significant difference among tolerance levels for the incremental costs of cleaning storage bins at the primary elevator. Confidence interval testing revealed that this component of costs was not significantly different from zero for any of the five tolerance levels. Cleaning the shipping components of the elevator, such as overhead bins and spouts, added significantly to the incremental costs of IP in System 1 at the lowest two tolerance levels of 0.5 percent and 0.1 percent, where the costs were $7.76 and $8.59 per 1000 tonnes respectively. The total mean cleaning cost estimates for System 1 at the primary elevator level ranged from $10.77 per 1000 tonnes at the 5 percent tolerance level to $51.56 at the 0.1 percent level. The summary statistics for confidence interval testing for System 1 can be seen in Table 5-21.

The mean cost estimates for cleaning the primary elevator in System 2 are given in Table 5-18, calculated per 1000 tonnes.

Table 5-18 Mean Incremental IP Costs of Mecnanical Cleaning at the Primary Elevator
System 2: Elevator designated to receive only non-GM wheat

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/1000 tonnes	$ -	$ -	$ 0.06	$ 0.76	$ 0.89
	(standard error)	*n/a*	*n/a*	(0.057)	(0.480)	(0.485)
Clean Storage	$/1000 tonnes	$ -	$ -	$ -	$ 0.38	$ 0.52
	(standard error)	*n/a*	*n/a*	n/a	(0.265)	(0.332)
Clean Shipping	$/1000 tonnes	$ -	$ -	$ 0.07	$ 0.32	$ 0.32
	(standard error)	*n/a*	*n/a*	(0.070)	(0.252)	(0.252)
Total Cleaning Costs ($/1000 tonnes)		$ -	$ -	$ 0.13	$ 1.47	$ 1.73

Costs in bold are significantly different from zero at the 95% significance level.

Costs listed as $ - represent mean estimates of $0.00.

Source: Estimates from seven primary elevator operators

For System 2, in which an elevator would be designated as non-GM only, ANOVA tests showed no significant differences between tolerance levels for the incremental cleaning costs at the primary elevator (see Table 5-20). This reflects that elevator facilities would rarely, if ever, have to be purged for GM wheat since they never receive GM wheat. The mean cost estimates increased from $0.00 to $0.89, from $0.00 to $0.52 and from $0.00 to $0.32 per 1000 tonnes for incremental cleaning costs of the receiving, storage and shipping components when moving from the tolerance levels of 5 percent to the 0.1 percent tolerance level, respectively. However, confidence interval testing showed no incremental cleaning costs that were significantly different from zero at any tolerance level (see Table 5-21). The estimated tolerance-sensitive cleaning costs for System 2 across tolerance levels increased from $0.00 per 1000 tonnes at the 5 percent and 3 percent tolerance levels, to $1.73 at the 0.1 percent tolerance level.

5.4.2 Capital Expenditures

Through interviews with primary elevator managers, it was ascertained that certain equipment would be needed to prevent adventitious contamination of non-GM IP wheat with GM wheat. Physical bin plugs and electronic lockout controls were cited as being possible additions to an elevator system that would handle both GM and non-GM IP wheat in a primary elevator. Seven primary elevator operators estimated the costs for these additional pieces of equipment along with the costs of installing and operating the auxiliary items. Following the suggestion of one manager and verification by two other managers, these costs were spread over a three-year period, as it was estimated that they would be in use for approximately that time. Thus, the total costs were divided by the expected amount of non-GM IP wheat over a three-year span. The respondents estimated costs for each of the two IP systems. The first system, System 1, involves an elevator that receives both non-GM and GM wheat. System 2 involves a designated system which receives only non-GM wheat. The estimated mean costs for System 1 are given in Table 5-19.

Table 5-19 Mean Incremental IP Costs of Capital Expenditure at the Primary Elevator
System 1: non-GM and GM wheat received within the same elevator

	Tolerance Level					
	Mean Costs	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Capital Expenditure	$/1000 tonnes	**$ 53.56**	**$ 53.56**	**$ 116.25**	**$ 192.55**	**$ 192.55**
	(standard error)	(20.593)	(20.593)	(27.955)	(57.545)	(57.545)

Costs in bold are significantly different from zero at the 95% significance level.

Source: Estimates from seven primary elevator operators

For the cost estimates of System 1, in which the primary elevator receives both non-GM and GM wheat, ANOVA tests indicated that significance differences in incremental costs for the different tolerance levels (see Table 5-20). Confidence interval tests indicated that the estimated costs at each of the five tolerance levels were significantly different from zero at the 95 percent level of significance (Table 5-21). The incremental costs for elevators based on the mean estimates for capital expenditure on various lock-out controls and physical plugs increased from $53.56 per 1000 tonnes at the 5 percent tolerance level to $192.55 at the 0.1 percent level of tolerance.

For the primary elevator in System 2 (non-GM only), no additional capital expenditures were reported. If GM wheat is not received in the facility, there is no need to install physical or electronic lockout equipment. Subsequently, the mean cost estimates for capital expenditure in System 2, across all tolerance levels, were $0.00 per 1000 tonnes.

Table 5-20 provides the ANOVA statistics for the estimated costs of cleaning receiving, storage and shipping equipment as well as for capital expenditure at the primary elevator level for both Systems 1 and 2. The single factor ANOVA tests for significant differences between the costs associated with various tolerance levels. Table 5-21 lists the confidence interval statistics for testing for significant differences from zero.

Table 5-20 Primary Elevator Level ANOVA Summary Statistics Testing Mean Estimates for Significance Among Tolerance Levels

	ANOVA Statistics		
System 1: Elevator Receives both non-GM and GM Wheat			
Primary Elevator Cost Point	*F-stat*	*P-value*	*F crit*
Clean Receving Pit and Leg	**4.10**	**0.01**	2.69
Clean Storage Bins	1.62	0.20	2.69
Clean Shipping Leg	**3.57**	**0.02**	2.69
Capital Expenditure	**2.93**	**0.04**	2.69
System 2: Elevator Receives only non-GM Wheat			
Primary Elevator Cost Point	*F-stat*	*P-value*	*F crit*
Clean Receving Pit and Leg	2.09	0.11	2.69
Clean Storage Bins	1.74	0.17	2.69
Clean Shipping Leg	1.06	0.39	2.69
Capital Expenditure	*n/a*	*n/a*	*n/a*

Bold F values and P-values indicate that there is significant differences between mean cost estimates at different tolerance levels for the specified cost point.

Table 5-21 Primary Elevator Level Confidence Interval Summary Statistics Testing Mean Estimates for Significant Difference from Zero

	Tolerance Level				
	5%	*3%*	*1%*	0.5%	0.1%
System 1: Elevator Receives both non-GM and GM Wheat					
Primary Elevator Cost Point	*Lower Bound of Confidence Interval (significant if greater than zero)*				
Clean Receiving Pit and Leg	-0.21	**1.32**	**1.75**	**4.58**	**6.96**
Clean Storage Bins	-1.64	-1.24	-1.32	-1.68	-0.07
Clean Shipping Leg	-0.42	-0.28	-0.44	**2.70**	**3.96**
Capital Expenditure	**3.17**	**3.17**	**47.85**	**51.74**	**51.74**
System 2: Elevator Receives only non-GM Wheat					
Clean Receiving Pit and Leg	*n/a*	*n/a*	-0.08	-0.42	-0.30
Clean Storage Bins	*n/a*	*n/a*	*n/a*	-0.27	-0.30
Clean Shipping Leg	*n/a*	*n/a*	-0.10	-0.29	-0.29
Capital Expenditure	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*

Bold confidence interval statistics indicate that the mean cost estimates are significantly different from zero at the 95% significance level, for each specified IP cost point.

5.4.3 Cumulative Estimates for Incremental IP Costs at the Primary Elevator

The incremental IP costs for non-GM wheat, which are sensitive to varying tolerance levels, are summarized in Table 5-22 for System 1. Table 5-23 summarizes the incremental IP costs for System 2. The incremental IP cost estimates are calculated based on the responses from seven primary elevator operators, six GM testing specialists and six IP coordinators. Other IP costs would be incurred at the primary elevator level, but those costs would not vary if the tolerance level changed and thus are not considered in this section. An extrapolation to include these other costs is, however, included in Section 5.8 in an analysis of aggregate costs.

Table 5-22 Mean Incremental IP Cost Estimates at the Primary Elevator Level
System 1: non-GM and GM wheat received within the same elevator

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/tonne	$ 0.00	$ 0.01	$ 0.01	$ 0.02	$ 0.02
Clean Storage	$/tonne	$ 0.01	$ 0.01	$ 0.01	$ 0.02	$ 0.02
Clean Shipping	$/tonne	$ 0.00	$ 0.00	$ 0.00	$ 0.01	$ 0.01
Capital Expenditure	$/tonne	$ 0.05	$ 0.05	$ 0.12	$ 0.19	$ 0.19
GM-Test Receiving	$/tonne	$ 0.03	$ 0.03	$ 0.06	$ 0.14	$ 0.28
GM-Test Shipping	$/tonne	$ 0.02	$ 0.02	$ 0.08	$ 0.19	$ 0.39
Total	$/tonne	$ 0.11	$ 0.11	$ 0.27	$ 0.57	$ 0.91

Costs listed as $0.00 are values greater than zero, but less than $0.01 per tonne.

Source: Estimates from seven primary elevator operators, six IP coordinators and six GM-Testing specialists.

Table 5-23 Mean Incremental IP Cost Estimates at the Primary Elevator Level
System 2: Elevator Designated to receive non-GM wheat and no GM wheat.

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/tonne	$ -	$ -	$ 0.00	$ 0.00	$ 0.00
Clean Storage	$/tonne	$ -	$ -	$ -	$ 0.00	$ 0.00
Clean Shipping	$/tonne	$ -	$ -	$ 0.00	$ 0.00	$ 0.00
Capital Expenditure	$/tonne	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
GM-Test Receiving	$/tonne	$ 0.03	$ 0.03	$ 0.06	$ 0.14	$ 0.28
GM-Test Shipping	$/tonne	$ -	$ -	$ -	$ -	$ -
Total	$/tonne	$ 0.03	$ 0.03	$ 0.06	$ 0.14	$ 0.28

Costs listed as $0.00 are values greater than zero, but less than $0.01 per tonne.

Source: Estimates from seven primary elevator operators, six IP coordinators and six GM-Testing specialists.

Figure 5-3 portrays the information from Table 5-22 for System 1 in a stacked bar graph. The figure clearly indicates the continued increase in primary elevator incremental IP costs at decreasing tolerance levels for GM content. The incremental costs for capital expenditure and GM testing at the receiving and shipping stage are much higher than are incremental cleaning costs associated with different tolerance levels.

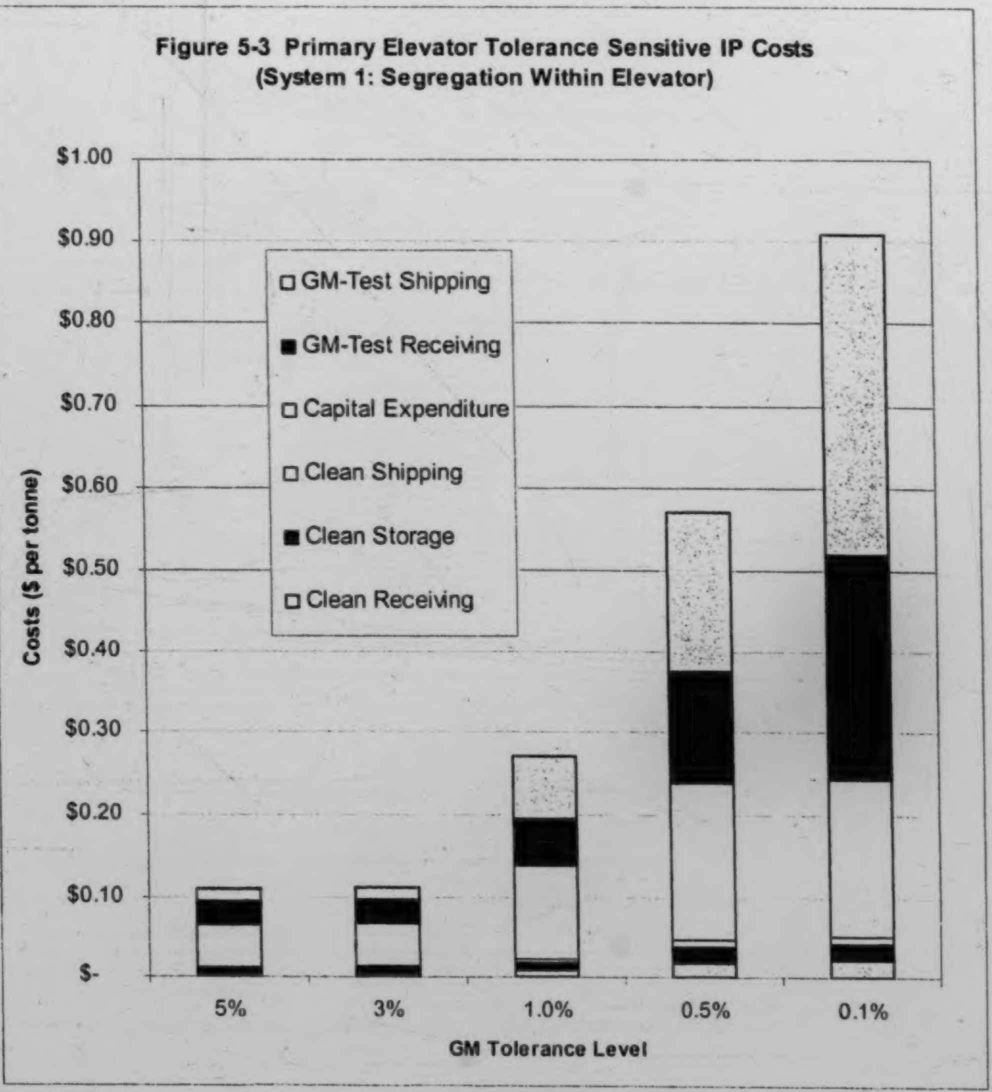


Figure 5-4 portrays the information from Table 5-23 for System 2 in a stacked bar graph. Primary elevator incremental IP costs increase as tolerance levels for GM content decrease. The estimated incremental cost is almost exclusively attributed to the GM testing upon reception of the non-GM wheat at the elevator, with less than $0.01 per tonne attributed to the various cleaning activities, while no cost is attributed to capital expenditures or GM testing at the time of shipping.

Figure 5-4 Primary Elevator Tolerance Sensitive IP Costs (System 2: Designated non-GM Elevator)

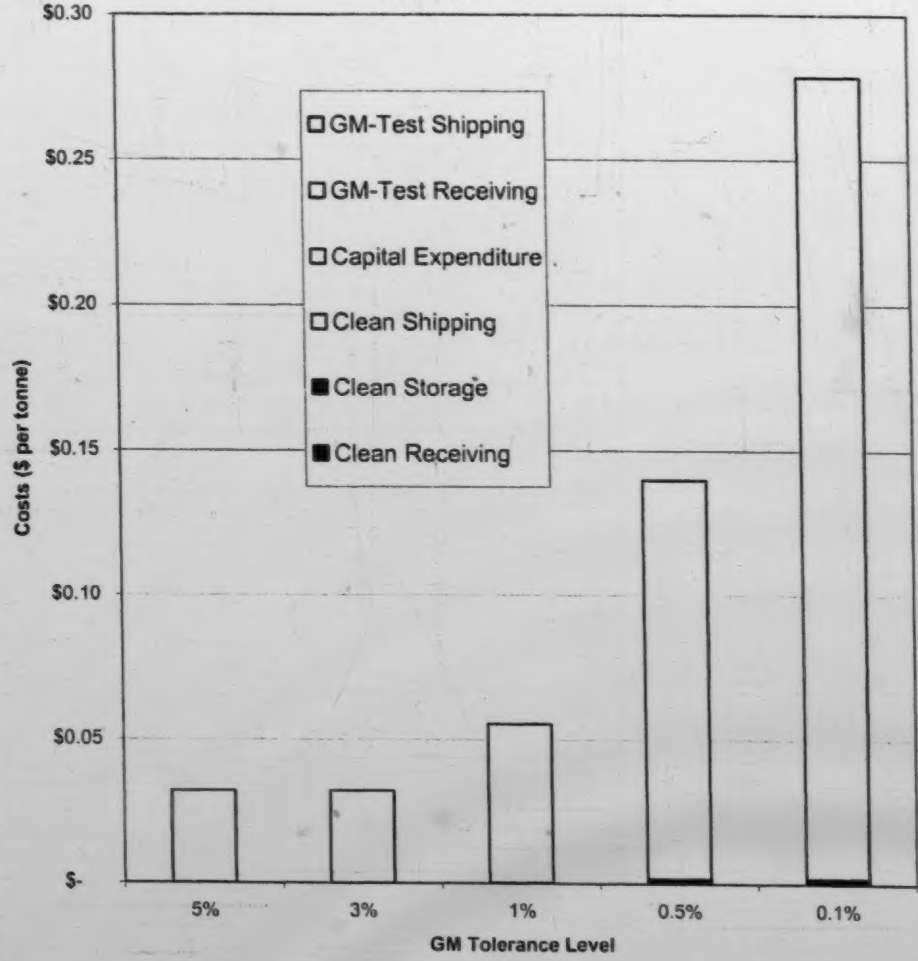


Figure 5-5 illustrates the comparison of the summation of the incremental cost functions that have been identified as tolerance-sensitive IP costs at the primary elevator level for supply Systems 1 and 2. In each case, there is a negative curvature that is apparently exponential, in the relationship between GM tolerance level and IP costs. The incremental IP costs for System 1 are more expensive than for System 2, and the costs are also more sensitive to lower tolerance levels, as can be seen by the widening of the distance between the incremental costs of the two systems as tolerance levels decline.

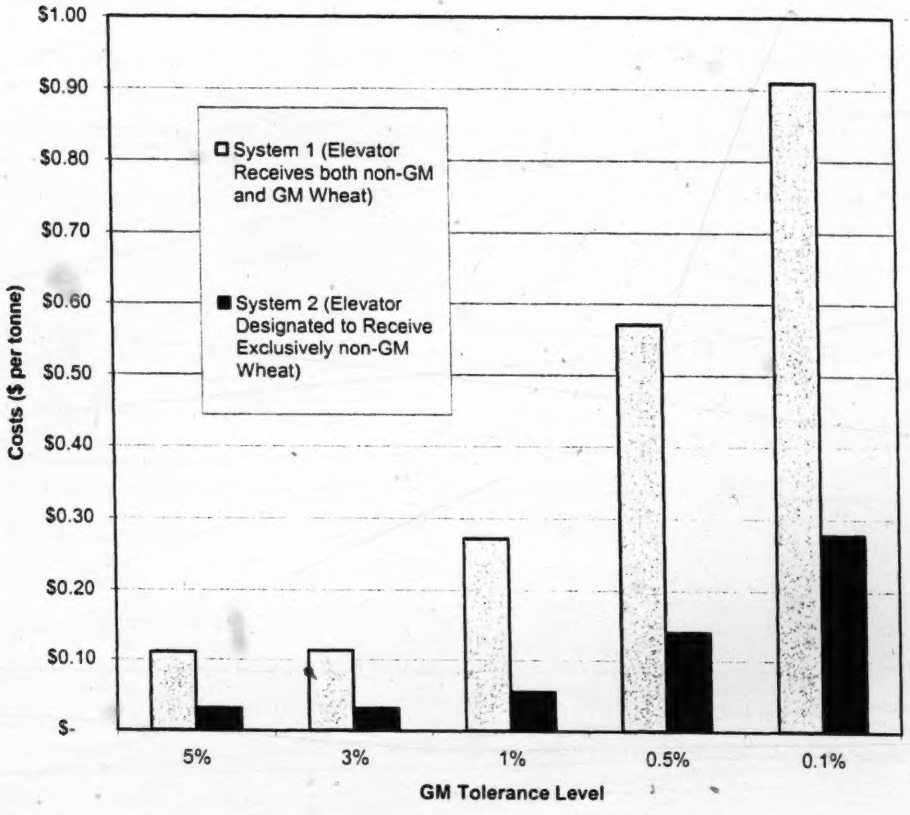


Figure 5-5 Total Primary Elevator Tolerance Sensitive IP Costs (Systems 1 and 2)

5.5 Incremental IP Costs at the Export Elevator Level

From initial interviews with export elevator managers, the major incremental costs that an export elevator is predicted to incur for a non-GM IP wheat program that would be sensitive to different tolerance levels for GM content were identified. It was determined that the incremental costs include: testing for GM content, cleaning of various items of equipment and capital expenditures for equipment such as lock-out systems and physical barriers to prevent contamination of non-GM consignments with GM crop material. Of the three IP systems scrutinized in this study, two systems involve an export elevator. Incremental costs at the export elevator that are associated with different tolerance levels are considered in this section for System 1, where primary and export elevators receive both non-GM and GM wheat, and System 2, where primary and export elevators receive only non-GM wheat.

Three export elevator operations managers were interviewed and asked to give their best estimates with regards to incremental IP cost and the effect of different tolerance levels on those costs, at their export facility. The interviews were based on a pre-designed survey that also included a hypothetical scenario (see Appendix A5). They responded in the context of the scenario presented to them for both System 1, where their export terminal would receive both non-GM and GM wheat, and for System 2, where this would receive only non-GM wheat.

The cost of GM testing for the export elevator level was outlined earlier in Section 5.3, based on estimates from a separate set of interviews with GM testing experts and IP coordinators. The incremental cleaning and capital cost estimates are initially calculated per 1000 tonnes, and reported on a cost per tonne basis.

5.5.1 Mechanical Cleaning Costs

Mechanical cleaning operations at the export elevator level are similar to those at the primary elevator in that they include the removal of crop residues from the grain handling and storage structures and from equipment within the elevator facility. Cleaning involves sweeping to eliminate any grain that may remain in various parts of the elevator system. The components of the facility that need to be considered for cleaning, as in the primary elevator, include the receiving pit and leg, storage bins and the shipping leg. The incremental costs of cleaning were calculated based on the time estimates reported by the three export elevator managers and a labour cost of $27.29 per hour, which was the reported wage of the unionized elevator labourers. For System 1, where the elevator would receive both non-GM and GM wheat, cleaning would typically take place before a unit train carrying non-GM wheat would unload. A unit train typically is made up of 100 rail hopper-cars, each holding 90 tonnes of wheat. Therefore, cleaning the system one time can be costed over 9000 tonnes of wheat. Table 5-24 presents the mean of the incremental cost estimates for cleaning at the export elevator, calculated per 1000 tonnes, for System 1.

For System 2, where the export elevator would not receive any GM wheat, it was reported that no additional cleaning of the equipment would be necessary before receiving non-GM IP wheat, and therefore, there would be no incremental IP costs involved relating to varying tolerance levels.

Table 5-24 Mean Incremental IP Cost Estimates of Mechanical Cleaning at the Export Elevator
System 1: non-GM and GM wheat received within the same elevator

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/1000 tonnes	$ 8.09	$ 10.11	$ 13.14	$ 15.16	**$ 20.21**
	(standard error)	(2.674)	(4.405)	(3.644)	(5.252)	(4.043)
Clean Storage	$/1000 tonnes	$ 2.02	$ 2.02	$ 4.04	$ 7.08	$ 10.11
	(standard error)	(2.021)	(2.021)	(2.021)	(4.405)	(5.053)
Clean Shipping	$/1000 tonnes	$ 4.04	$ 4.04	$ 8.09	$ 9.10	$ 9.10
	(standard error)	(1.010)	(1.010)	(2.021)	(3.032)	(3.032)
Total Cleaning Costs ($/1000 tonnes)		$ 14.15	$ 16.17	$ 25.27	$ 31.33	$ 39.42

Costs in bold are significantly different from zero at the 95% significance level.
Source: Estimates from three export elevator operators

The incremental costs for cleaning the receiving components increased from $8.09 to $20.21 per 1000 tonnes as tolerance levels decreased from the 5 percent level to the 0.1 percent tolerance level. Incremental costs for cleaning the storage facilities, again calculated per 1000 tonnes, grew from $2.02 to $10.11 at the 5 percent and 0.1 percent tolerance levels respectively. The incremental IP costs for cleaning the shipping equipment ranged from $4.04 to $9.10 per 1000 tonnes.

Considering System 1, a series of ANOVA tests of significance between incremental costs across tolerance levels for the three specified cleaning points revealed no significant differences in the costs of cleaning for the different tolerance levels (see Table 5-26). However, confidence interval testing revealed that cleaning the receiving pit and legs, at a cost of $20.21 per 1000 tonnes, was significantly different from zero at the 95 percent significance level. The results of the confidence interval testing which tests each mean for its significant from zero are given in Table 5-27.

5.5.2 Capital Expenditures

At the export elevator level, capital purchases were reported as necessary for certain equipment to help prevent adventitious co-mingling of non-GM and GM wheat for an elevator in System 1 that would receive both. In System 2, where the elevator would not receive GM wheat, no additional capital expenditures would need to be made. System 1 would require certain physical plugs and covers for the storage and handling system to prevent GM grain from accidentally "trickling" into a bin storing non-GM wheat. As with the cost calculations for primary elevators, the incremental costs of these capital expenditures at the export elevator level were costed out over a three year period, the suggested length of time that they would be likely to be useful. Table 5-25 shows the estimated mean incremental costs of these capital expenditures at the export elevator level for System 1.

Table 5-25 Mean Costs of Capital Expenditure at the Export Elevator
System 1: non-GM and GM wheat received within the same elevator

		Tolerance Level				
	Mean Costs	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Capital Expenditure	$/1000 tonnes	$ 5.80	$ 5.80	**$ 48.32**	**$ 48.32**	**$ 54.12**
	(standard error)	(5.797)	(5.797)	(11.031)	(11.031)	(8.764)

Costs in bold are significantly different from zero at the 95% significance level.
Source: Estimates from three export elevator operators

As the tolerance level decreased, this component of incremental costs increased from $5.80 per 1000 tonnes at the 5 percent tolerance level to $54.12 per 1000 tonnes at the 0.1 percent level. An ANOVA test revealed that there are significant differences among the incremental costs at the different tolerance levels (see Table 5-26). Confidence interval testing revealed that the costs of $48.32 per 1000 tonnes at 1 percent and 0.5 percent tolerance levels and $54.12 per tonne at the 0.1 percent tolerance level were significantly different from zero at the 95 percent significance level (Table 5-27).

The ANOVA statistics for the incremental cleaning costs and capital expenditure are listed in Table 5-26. An F statistic higher than the F critical value implies that there are significant differences among the costs across the different tolerance levels. The lower bounds of the confidence intervals for each tolerance level are listed in Table 5-33. Since the mean costs for each tolerance level are strictly positive, a positive lower bound indicates that the 95 percent confidence interval associated with that mean does not include zero, indicating that the mean is statistically different from zero.

Table 5-26 Export Elevator Level ANOVA Summary Statistics
Testing Mean Estimates for Significance Among Tolerance Levels
System 1: Elevator Receives both non-GM and GM Wheat

	ANOVA Statistics		
Export Elevator Cost Point	*F-stat*	*P-value*	*F crit*
Clean Receving Pit and Leg	1.32	0.33	3.48
Clean Storage Bins	1.07	0.42	3.48
Clean Shipping Leg	1.40	0.30	3.48
Capital Expenditure	**7.72**	**0.00**	3.48

Bold F values and P-values indicate that there is significant differences between mean cost estimates at different tolerance levels for the specified cost point.

Table 5-27 Export Elevator Level Confidence Interval Summary Statistics
Testing Mean Estimates for Significant Difference from Zero
System 1: Elevator Receives both non-GM and GM Wheat

	Tolerance Level				
	5%	*3%*	*1%*	0.5%	0.1%
Primary Elevator Cost Point	*Lower Bound of Confidence Interval (significant if greater than zero)*				
Clean Receving Pit and Leg	-3.420	-8.849	-2.540	-7.436	2.819
Clean Storage Bins	-6.676	-6.676	-4.655	-11.881	-11.637
Clean Shipping Leg	-0.306	-0.306	-0.612	-3.950	-3.950
Capital Expenditure	-19.146	-19.146	**0.855**	**0.855**	**16.404**

Bold confidence interval statistics indicate that the mean cost estimates are significantly different from zero at the 95% significance level, for each specified IP cost point.

5.5.3 Cumulative Export Elevator Incremental IP Costs

The tolerance-sensitive incremental IP costs for non-GM wheat at the export elevator level are summarized in Table 5-28 for System 1. Table 5-29 summarizes the incremental IP costs for System 2. These are reported on a per tonne basis and include the incremental costs of GM testing which were calculated and discussed earlier in Section 5.3.

Table 5-28 Mean Incremental IP Cost Estimates at the Export Elevator Level
System 1: non-GM and GM wheat received within the same elevator

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/tonne	$ 0.01	$ 0.01	$ 0.01	$ 0.02	$ 0.02
Clean Storage	$/tonne	$ 0.00	$ 0.00	$ 0.00	$ 0.01	$ 0.01
Clean Shipping	$/tonne	$ 0.00	$ 0.00	$ 0.01	$ 0.01	$ 0.01
Capital Expenditure	$/tonne	$ 0.01	$ 0.01	$ 0.05	$ 0.05	$ 0.05
GM-Test Receiving	$/tonne	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.08
GM-Test Shipping	$/tonne	$ 0.01	$ 0.02	$ 0.03	$ 0.06	$ 0.21
Total	$/tonne	**$ 0.11**	**$ 0.12**	**$ 0.18**	**$ 0.22**	**$ 0.38**

Costs listed as $0.00 are values greater than zero, but less than $0.01 per tonne.

Source: Estimates from three export elevator operators, six IP coordinators and six GM-Testing specialists.

Table 5-29 Mean Incremental IP Cost Estimates at the Primary Elevator Level
System 2: Elevator Designated to receive non-GM wheat and no GM wheat.

		Tolerance Level				
Cleaning Points	**Mean Costs**	*5%*	*3%*	*1%*	*0.5%*	*0.1%*
Clean Receiving	$/tonne	$ -	$ -	$ -	$ -	$ -
Clean Storage	$/tonne	$ -	$ -	$ -	$ -	$ -
Clean Shipping	$/tonne	$ -	$ -	$ -	$ -	$ -
Capital Expenditure	$/tonne	$ -	$ -	$ -	$ -	$ -
GM-Test Receiving	$/tonne	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.08
GM-Test Shipping	$/tonne	$ 0.01	$ 0.02	$ 0.03	$ 0.06	$ 0.21
Total	$/tonne	**$ 0.09**	**$ 0.09**	**$ 0.11**	**$ 0.14**	**$ 0.28**

Costs listed as $ - are zero cost values.

Source: Estimates from three export elevator operators, six IP coordinators and six GM-Testing specialists.

Similar to primary elevators, export elevators would incur other costs to operate an IP system besides the cost of cleaning, capital expenditure and GM testing that would not be sensitive to varying tolerance levels such as maintaining the correct paper trail, managing the system and training employees. Consequently, these are not considered in this section. However, fixed IP costs are referred to in Section 5.8 where total aggregate costs are considered.

Figure 5-6 depicts the information from Table 5-28 for System 1 in a stacked bar graph, showing the incremental cost increases as tolerance levels decrease. Capital expenditure and GM testing at receiving and shipping points are the most sensitive of these components to changes in tolerance levels.

Figure 5-6 Export Elevator Tolerance Sensitive IP Costs (System 1: Segregation of non-GM and GM Wheat within Elevator)

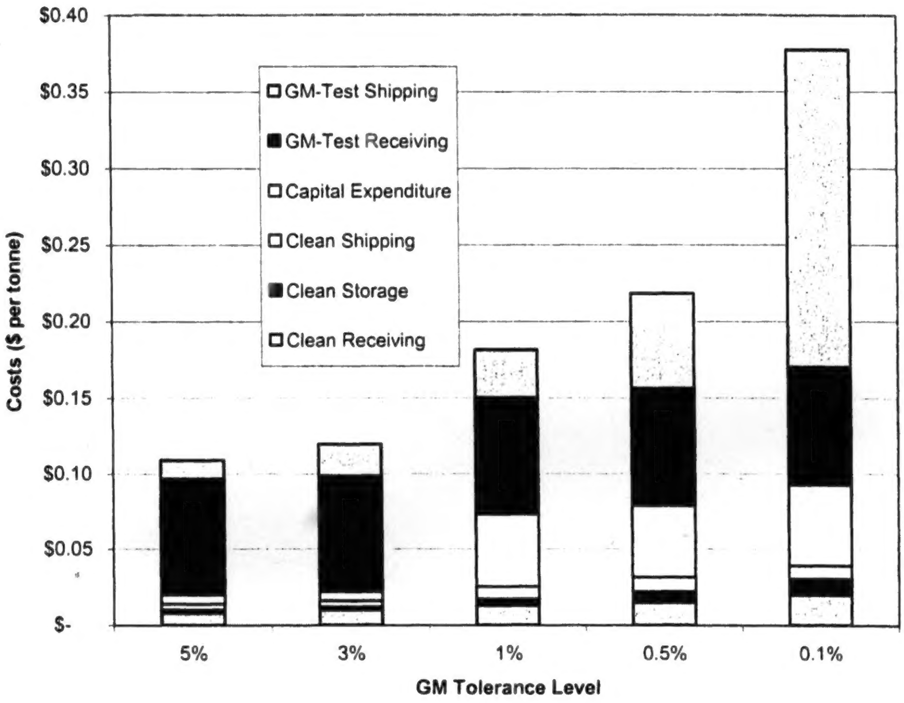


Figure 5-7 portrays the information from Table 5-29 for System 2 in a stacked bar graph. For this system, incremental tolerance-sensitive IP costs increase as tolerance levels decrease. The incremental IP costs consist entirely of GM testing costs. No incremental cleaning or capital expenditure costs are necessary in System 2.

Figure 5-7 Export Elevator Tolerance Sensitive IP Costs (System 2: Designated to Receive non-GM Wheat only)

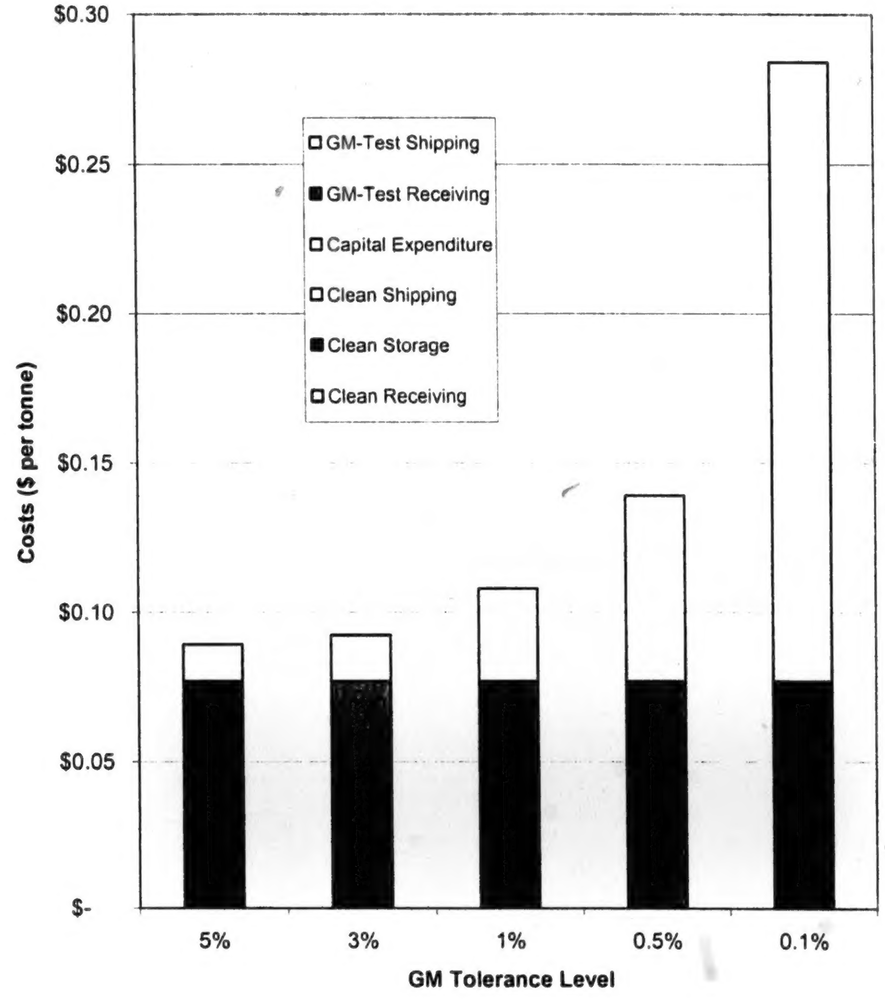
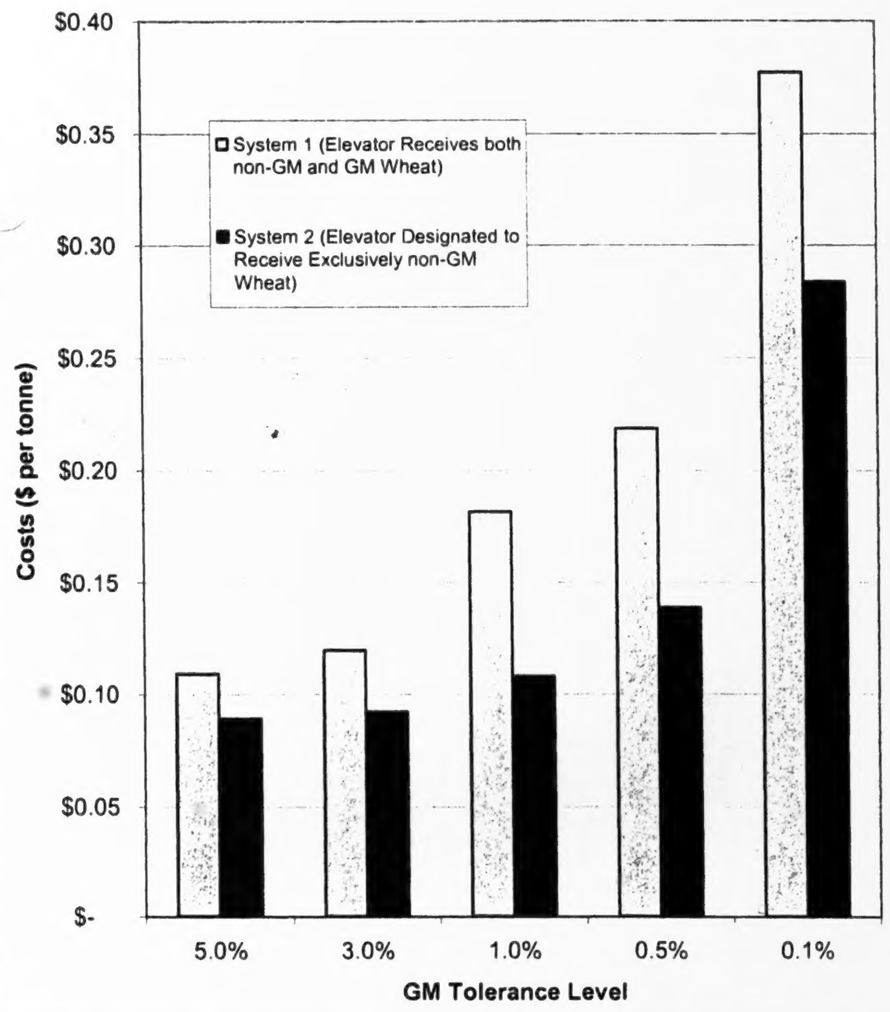


Figure 5-8 illustrates the comparison between Supply Systems 1 and 2 for incremental IP costs at the export elevator level. There is a clear indication of a negative relationship between tolerance level and IP costs. The incremental IP costs are higher for System 1 where the export elevator receives both non-GM and GM wheat than for System 2 where the export elevator receives only non-GM wheat.

Figure 5-8 Export Elevator Tolerance Sensitive IP Costs (Systems 1 and 2)



5.6 Containerization

Based on preliminary interviews with containerization specialists, the only GM tolerance-sensitive cost for non-GM IP wheat that is identified is the cost of conducting GM testing. Under the scenario considered for this study, the quantity, approximately 220 tonnes, of non-GM wheat that is produced on one farm would initially be stored in a bin at the farm. When it was time to ship the wheat, the farmer would load this into 9 containers, each holding a maximum of about 27 tonnes of wheat (Daoust 2003). Section 5.3 discusses the GM testing methods used for this system (System 3). Table 5-16 shows the incremental costs for the GM tests at the different tolerance levels to be $1.43 per PCR test at each tolerance level. Based on estimates by the interviewed experts, the GM testing costs are $1.43 per tonne for all tolerance levels as shown in Table 5-30. Despite the fact that interviewees determined GM testing for containers to be tolerance-sensitive, under the given scenario, the testing costs are not tolerance-sensitive.

If a farmer grew a lot more non-GM IP wheat, the GM-testing costs could be tolerance-sensitive if more than one test was required at the farm level for the lower tolerance levels but not for the higher levels.

5.7 Total Incremental Tolerance-Sensitive IP Costs for Three Supply Chains

The incremental IP costs for each system are based on estimates that were provided for each stage of all three supply chains and across all five tolerance levels. Table 5-30 summarizes these incremental cost estimates by adding together the estimates from each stage of each supply chain and for each tolerance level.

Table 5-30 Tolerance Sensitive Costs For Three Supply Chain Systems

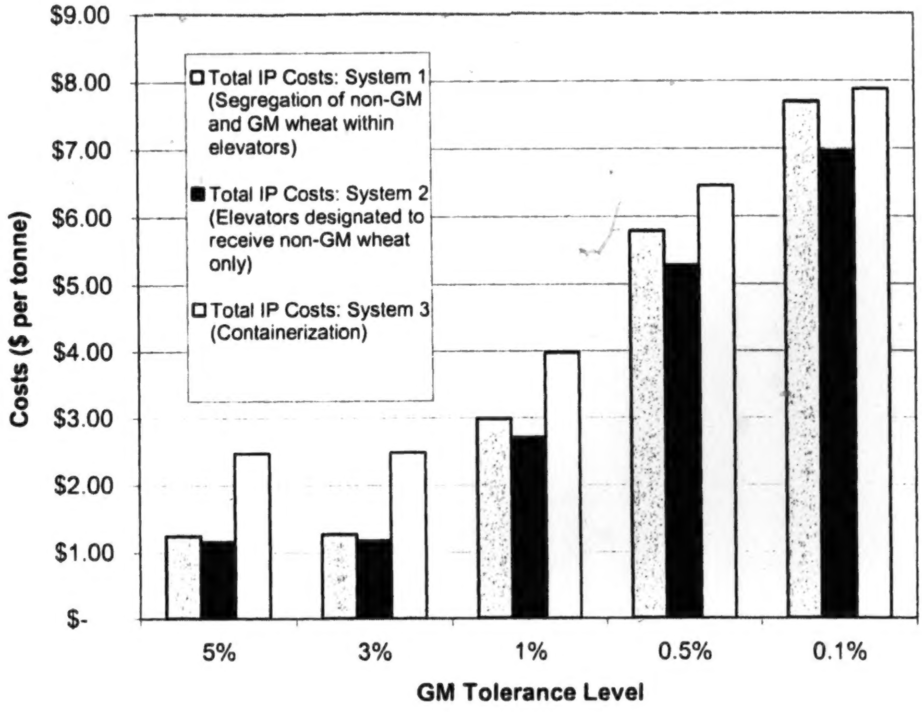
System 1: non-GM and GM wheat received within the same elevators
System 2: Elevators designated to receive non-GM wheat and no GM wheat.
System 3: Containerization

		Tolerance Level				
		5%	3%	1%	0.5%	0.1%
System 1	Farm Level	$ 1.04	$ 1.06	$ 2.55	$ 5.03	$ 6.45
	Primary Elevator	$ 0.11	$ 0.11	$ 0.27	$ 0.57	$ 0.91
	Export Elevator	$ 0.11	$ 0.12	$ 0.18	$ 0.22	$ 0.38
Total System 1		**$ 1.26**	**$ 1.29**	**$ 3.00**	**$ 5.82**	**$ 7.74**
System 2	Farm Level	$ 1.04	$ 1.06	$ 2.55	$ 5.03	$ 6.45
	Primary Elevator	$ 0.03	$ 0.03	$ 0.06	$ 0.14	$ 0.28
	Export Elevator	$ 0.09	$ 0.09	$ 0.11	$ 0.14	$ 0.28
Total System 2		**$ 1.16**	**$ 1.18**	**$ 2.71**	**$ 5.31**	**$ 7.02**
System 3	Farm Level	$ 1.04	$ 1.06	$ 2.55	$ 5.03	$ 6.45
	GM-Testing	$ 1.43	$ 1.43	$ 1.43	$ 1.43	$ 1.43
Total System 3		**$ 2.47**	**$ 2.48**	**$ 3.98**	**$ 6.46**	**$ 7.88**

Sources: Interview Respondents

Figure 5-9 presents the incremental IP costs of all three supply chains in a clustered column graph format for comparison across tolerance levels. From this graph, it is clear that tolerance levels have an appreciable effect on incremental costs associated with varying threshold levels for all three supply chains. It can be noted that the incremental costs for System 3, which is the containerization system, are the highest for each tolerance level while System 2, where the primary and export elevators receive only non-GM wheat, has the lowest costs. System 1, in which the elevators receive non-GM and GM wheat, lies between the other two systems in terms of incremental IP costs, at each tolerance level.

Figure 5-9 Incremental Tolerance-Sensitive IP Costs for Three Supply Chains



It can be noted that the ratio of incremental costs changes as tolerance levels decrease. Containerization is the least sensitive of the three supply systems to changes in tolerance level. At the 5 percent tolerance level, System 1 has incremental costs of $1.26 per tonne compared to $2.47 per tonne for System 3, a difference of $1.21. However, at the 0.1 percent tolerance level, System 1 costs increased to $7.74 while System 3 costs increased to $7.88, a difference of only $0.14 per tonne.

5.8 Aggregate Costs for Identity Preserved CWRS Wheat: From Farm to Ship

The analyses of the three supply chains that have been examined in this study thus far have included only those incremental IP costs involved with the production, handling and shipping of non-GM wheat that are sensitive to varying tolerance levels. Clearly, each supply chain has other costs associated with production, handling, and shipping besides those that are apt to change as tolerance levels change. These are considered in this section, in addition to the tolerance-sensitive costs that have been estimated up to this point, in order to present an aggregate cost estimate for each supply chain. The aggregate costs are presented on a per tonne basis at all stages of each supply chain and for each tolerance level. The costs for supply Systems 1 and 2, which involve the shipment through elevators are expected to have identical costs except for the tolerance-sensitive costs. Supply System 3, which involves containerization, has identical costs as the two supply systems, which involve elevators, at the production level only, after which the costs are different.

5.8.1 Non-Tolerance Sensitive Costs for CWRS Wheat (Systems 1 and 2)

In the Central Alberta region, production costs for CWRS wheat at the farm level for all three supply chains are taken to be $136.45 per tonne inclusive of direct expenses as well as capital costs such as land rent, depreciation and capital interest based on data from Alberta Agriculture (AAFRD, 2002-03b). For the two elevator systems, shipping costs from the farm to the primary elevator are taken to be approximately $4 per tonne (AAFRD, 2002) and the primary elevator tariff costs (fees and levies that the elevator charges for handling grain) are taken to be $11.25 per tonne as of July 2003 (Goyeau, 2003). The cost per tonne of wheat shipped via rail from Edmonton to Vancouver is $28.35 per tonne as of July 2003 (Daoust, 2003) and the tariff rate for the export elevators in July 2003 is approximately $7.80 per tonne (Goyeau, 2003). Summing these costs, base costs for producing, elevating and transporting CWRS from Central Alberta to Vancouver through the elevator handling system is taken as $187.85 per tonne (as shown in Table 5-31).

For non-GM IP wheat, besides the base costs noted above and the tolerance-sensitive IP costs, which have been estimated in this study, there are also non-tolerance-sensitive IP costs which need to be considered in the total cost approximation. Since these costs do not vary as tolerances levels change, they are considered to be fixed IP costs.

These non-tolerance-sensitive costs include using certified seed instead of common seed at the farm-level (Haarsma, 2003). It is also estimated that there would be IP costs of approximately $0.30 per tonne attributed to employee management, employee training, and legal contract costs at the primary and export elevators combined (Sparks, 2000; Vanderkylen, 2003; Young, 2003). An additional $3.75 per tonne is assumed to apply for coordination of the IP system from the farm-level to the point where the wheat is loaded on the vessel at port (Sparks, 2000; Vanderkylen, 2003; Young, 2003; Reid, 2003). Different parties involved in the IP process, depending on the contract stipulations, may incur these additional coordination costs. The costs include field inspections, on-farm consultations, farmer-training and additional paper work (Sparks, 2000, Vanderkylen, 2003, Young, 2003, Reid, 2003).

For both Supply Chain Systems 1 and 2, the IP costs for non-GM wheat that are not tolerance-sensitive are approximated to be $5.55 per tonne. The costs involved with identity preserved non-GM wheat, from farm to port, before tolerance-sensitive costs are considered, are taken as $193.40 per tonne for both Supply Systems 1 and 2 (see Table 5-31).

Table 5-31 Costs from Farm to Port for non-GM IP CWRS Wheat Elevator Systems 1 & 2 (Not Including Tolerance-Sensitive IP Costs)

Costs	$/Tonne	
Farm Production	$	136.45
Transport to Elevator	$	4.00
Primary Elevator Tariff	$	11.25
Transport to Port	$	28.35
Export Elevator Tariff	$	7.80
Total Base Costs: Farm to Port	**$**	**187.85**
Fixed IP: Farm (certified seed)	$	1.50
Fixed IP: Elevators (training, legal costs)	$	0.30
Coordination at all Levels	$	3.75
Total Fixed IP Costs	**$**	**5.55**
Farm to Port Costs before tolerance-sensitive costs	**$**	**193.40**

5.8.2 Costs of Containerization (Exclusive of Tolerance-Sensitive Costs)

As mentioned previously, the farm-level costs for the containerization system are assumed to be the same as for wheat moved through the two elevator systems, $136.45 per tonne (AAFRD, 2002-03b). It is assumed for this study that 27 tonne (60,000lbs) containers are used to ship non-GM wheat from an inter-modal terminal in Central Alberta to the port of Vancouver. After-farm costs for containerization include local drayage and shipping costs to Vancouver of $42.03 per tonne (Daoust, 2003), viewed as a typical cost estimate, subject to variation in farm location (Snider, 2003). Local drayage consists of shipping the container to and from the local inter-modal terminal and will vary according to the location of the farm in relation to an inter-modal terminal where containers can be loaded onto a train. Additional freight and handling costs include a fuel surcharge of 4 percent (Daoust, 2003), equaling $1.68 per tonne as of July 2003, as well as container handling charges at the export terminal of $7.56 per tonne as of July 2003 (Goyeau, 2003). A further cost to consider for container shipping of wheat involves buy-back cost charges applied by the Canadian Wheat Board (CWB), which can vary significantly (Snider, 2003). Buy-back costs can be as high as $25.00 per tonne (Cobb, 2003). Fixed IP costs for shipping non-GM wheat via containers are taken to be $5.25 per tonne. These costs include the extra cost of $1.50 per tonne produced for certified seed at the farm level as well as the IP coordination costs of $3.75 per tonne, considering that field inspections, farmer training and extra paper work will still be required.

Before including tolerance-sensitive IP costs, assuming $25.00 per tonne for buy-back costs, the cost for producing, shipping and handling CWRS wheat in Central

Alberta and shipping it to Vancouver via container is $214.21 per tonne. The breakdown of the base costs for containerization is given in Table 5-32.

Table 5-32 Costs from Farm to Port for non-GM IP CWRS Wheat
For Containerization, Supply System 3
(Not Including Tolerance-Sensitive IP Costs)

	$/Container	**$/tonne**
Farm Production Costs		$ 136.45
Total Freight, Local Drayage etc.	$ 1,144.00	$ 42.03
Fuel Surcharge (4%)	$ 45.76	$ 1.68
Port Drayage	$ 204.00	$ 7.56
Buy-Back		$ 25.00
Fixed IP Cost		$ 5.25
TOTAL		**$ 217.96**
Assumes container holds 60000 lbs (27 tonnes)		

Figure 5-10 portrays the information in Tables 5-31 and 5-32. The bar graph shows the aggregate costs of an elevator system compared to a containerization system for wheat, before the inclusion of tolerance-sensitive costs.

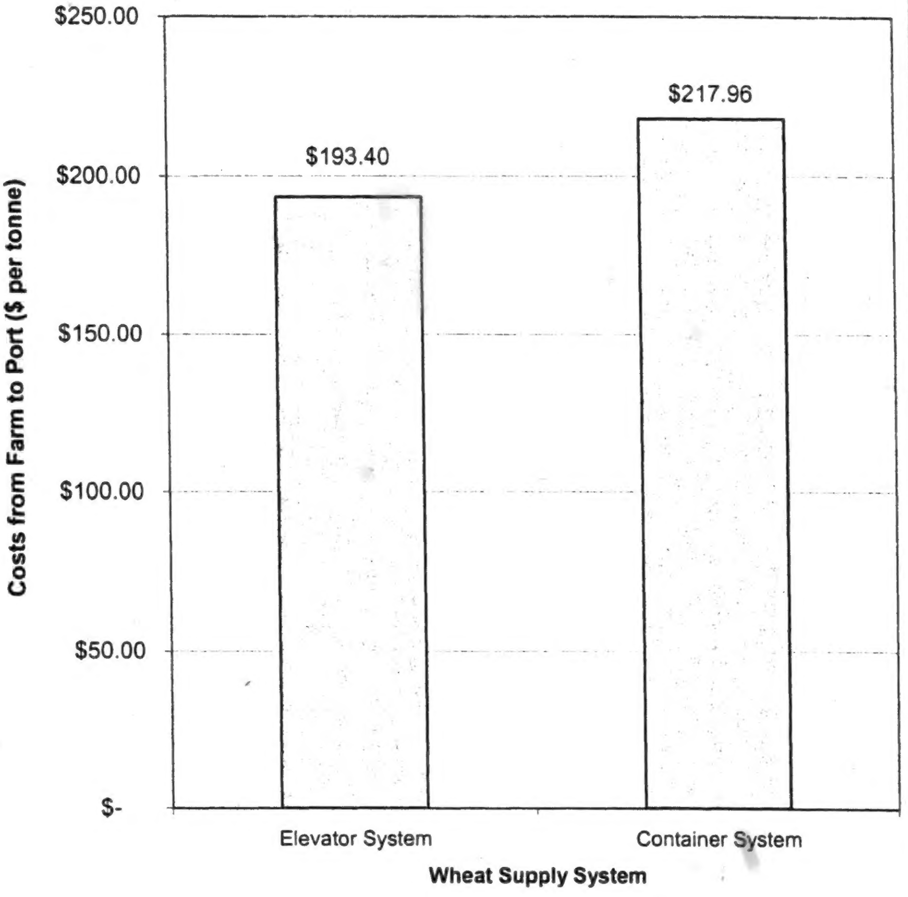


Figure 5-10 Aggregate Cost Comparison of IP Elevator amd Container Systems for CWRS Wheat (Not Including Tolerance-Senstive Costs)

5.8.3 CWRS Wheat System Costs, Including Tolerance-Sensitive Costs

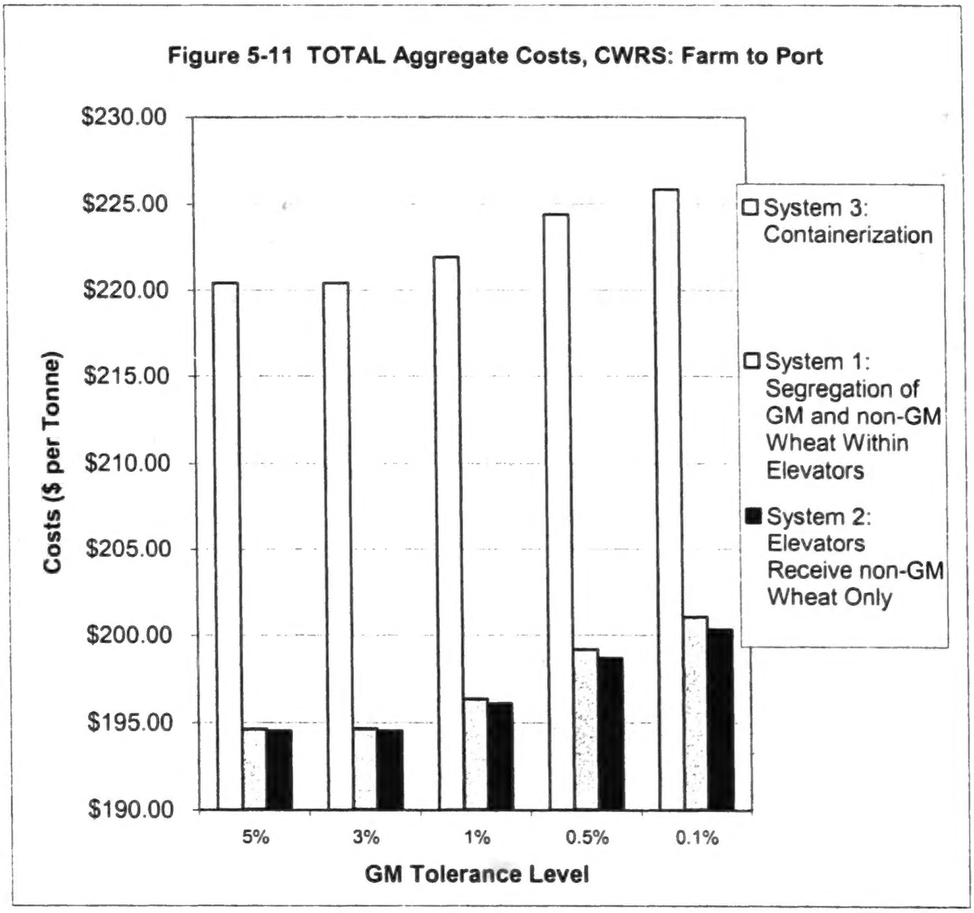
The approximation of total aggregate costs from on-farm production in Alberta, including shipping and handling to the point of being loaded on an ocean vessel in Vancouver, include the estimated tolerance-sensitive IP costs, summarized in Table 5-30, for all three supply chains across the different tolerance levels. These estimates are given in Table 5-33.

Table 5-33 Total Aggregate Costs, CWRS Wheat: Farm to Port
Comparison of Three Alternate Supply Systems Across Tolerance Levels

	5%	3%	1%	0.5%	0.1%
System 1: Segregation Within	$ 194.66	$ 194.68	$ 196.39	$ 199.19	$ 201.09
System 2: Designated Elevators	$ 194.56	$ 194.57	$ 196.10	$ 198.68	$ 200.37
System 3: Containerization	$ 220.43	$ 220.44	$ 221.94	$ 224.42	$ 225.84

System 1 involves primary and export elevators which receive non-GM and GM wheat.
System 2 involves primary and export elevators which don't receive any GM wheat.
System 3 involves conterization of wheat from farm to end consumer.

Figure 5-11 summarizes the estimates given in Table 5-33. This depicts the aggregate cost estimates, including the tolerance-sensitive costs, for each of the three supply systems.



The graph illustrates the cost gap that exists between the elevator systems and containerization. The cost gap narrows between System 1 (segregation of GM and non-GM within elevators) and Systems 3 (containerization) as tolerance levels become more stringent. System 3 is $0.39 per tonne closer to System 1, in terms of costs, at the 0.1 percent tolerance level than at the 5 percent tolerance level. A widening of the cost gap between the System 1 and System 2 (elevators receive only non-GM wheat) as tolerance levels tighten is also apparent with System 2 being $0.10 per tonne cheaper at the 5 percent level and $0.72 cheaper at the 0.1 percent tolerance level.

5.9 Respondents' Views of Feasible GM Tolerance Levels

One of the final questions discussed with the interviewed seed growers was: "At what tolerance would you feel that you would not consider growing non-GM wheat, despite an acceptable premium, because it would be too difficult or too risky or even impossible to do?" (see Appendix A1). One responding seed grower estimated that any tolerance level below 2 percent would not be practical on his farm and one responded that less than 1 percent would be an unrealistic tolerance level for his operation. Another respondent indicated that less than 0.5 percent would not be worth the risk of contamination and loss of premium after sinking costs into IP procedures. However, ten of the fourteen[9] seed growers said that with an acceptable premium, they were confident that they could be successful in the IP of non-GM wheat at the 0.1 percent tolerance level. Among the ten farmers who estimated that they could successfully meet a 0.1 percent tolerance level, seven stated that they would not grow GM wheat in the same year that they would grow non-GM IP wheat if they had to use the same equipment and storage facilities. However, three farmers were confident that they could successfully grow non-GM IP wheat and GM wheat in the same year using the same equipment. They suggested that more (a higher level of) management would likely be necessary to ensure that the stricter tolerance levels could be met. Scheduling operations such as planting and harvesting any GM wheat only after all these operations for non-GM wheat was finished was one practice they would assume in order to lessen the likelihood of contamination through adventitious mixing through use of various pieces of equipment. The inconvenience of this practice could be minor, or it could entail some costs, which are not considered here.

Primary elevator managers were asked two specific questions pertaining to the feasibility of meeting certain tolerances in receiving, handling, and shipping grain (see Appendix A2). The first question was, "At what tolerance level for GM content in non-GM IP wheat would it be necessary to designate a separate elevator in order to ensure that the tolerance level requirements could be met." The second question asked, "At what tolerance level would containerization be necessary to ensure that the tolerance requirements could be met." Among primary elevator managers, the general consensus (six of seven interviewees) was that at a 1 percent tolerance level, an elevator could "quite feasibly" handle both GM and non-GM wheat through the same pit and elevator system with the necessary lockouts and plugs in place and with the proper cleaning practices. One respondent said that 0.5 percent would be feasible to achieve in a "mixed" system. Below 1 percent tolerance level, most operators perceived that they would need a designated elevator system with a separate pit to confidently segregate non-GM IP wheat to achieve the lower tolerance levels. (However, one operator indicated that only below 0.5 percent tolerance, would a designated system would be necessary.) All seven primary elevator operators indicated that with a designated system, a tolerance of 0.1 percent GM content within non-GM IP wheat could be met. Only at levels stricter than this, approaching zero

---

[9] One respondent did not answer this question.

tolerance, would they not feel confident that they could meet the requirements, making on-farm containerization a necessity.

The same questions on elevator capabilities were posed to the three export elevator operation-managers interviewed (see Appendix A5). All three managers responded that a designated elevator would not be necessary at any of the presented tolerance levels. One respondent said that they already segregated within the levels of 0.5 percent and 0.1 percent for other products currently in the system. These respondents also suggested that containerization would not be necessary assuming that the tolerance level was greater than zero, unless a contract specifically required this.

CHAPTER 6

Conclusions and Discussion

6.1 Conclusions and Discussion

The impacts of biotechnology on agriculture are expected to be considerable. These products do not come without opposition and meet resistance by many consumers. Consequently, the licensing of genetically modified (GM) wheat in Western Canada poses many challenges. In developing a system that will provide GM-averse wheat consumers with non-GM wheat; the effects of different tolerance levels for GM content within non-GM wheat can have appreciably different economic effects on the identity preservation (IP) supply system.

The main objective of this study was to estimate how different tolerance levels would affect the costs of supplying wheat to export consumers demanding non-GM IP wheat. The scenario within which this is pursued assumes that some 50 percent of Western Canada's CWRS is non-GM, contracted under IP programs. Individuals that were recognized to have expert knowledge about the operational characteristics of the different stages of the supply chain for Western Canadian wheat were identified. Estimates were gathered from these knowledgeable individuals as to the measures that would need to be employed to meet particular specified tolerance requirements. In addition, these individuals were queried as to the cost of the procedures that would be necessary to meet the specified different tolerance requirements at their particular stage in the supply chain. Three different supply chains were considered and costs were compared across the five different specified tolerance levels.

The main hypothesis of the study is that identity preservation (IP) costs increase as the tolerance level decrease. The basis for this hypothesis is that lower tolerances for GM content within a non-GM system would require added scrutiny and care at each level of handling, leading to increased costs. Based on this expectation, it was expected that the costs of IP and the stated tolerance level would be inversely related.

The hypothesis was supported in that increasing tolerance levels have an appreciable effect on costs of identity preserving non-GM wheat. This effect was predominantly evident at the farm level, particularly for the costs of controlling GM wheat volunteers and maintaining adequate isolation zones, where the costs varied considerably across tolerance levels. The costs related to the identity preservation of non-GM wheat were determined to be sensitive to yield when costed out per tonne of wheat produced.

Two different isolation zone methods were indicated as "likely to be used" by the seed growers who were interviewed in this study. Method 1, where the entire field would be planted with non-GM wheat and a buffer strip of a specific width around the outside of the field would be harvested and marketed separately, was determined to be cheaper at all tolerance levels than was Method 2, which would involve cultivating and maintaining a bare isolation zone.

It was determined that Supply Chain System 1, where non-GM wheat and GM wheat were both received by the same primary and export elevators, would be the grain handling system most sensitive to varying tolerance levels. The costs associated with IP in a "mixed" handling system increased at a sharper rate than for the other two systems considered in this study. Supply Chain System 3, where non-

GM wheat was containerized on the farm, was the least sensitive of the three systems to changing tolerance levels. For Identity Preservation Supply Chain System 2 (in which designated elevators would receive only non-GM wheat and no GM wheat) as well as for Supply Chain System 1 as outlined above, handling costs increase as tolerance levels decrease. System 2 is less sensitive to changes in tolerance levels, and thus became increasingly more cost efficient, relative to System 1, in handling non-GM wheat as tolerance levels for adventitious contamination declined. The process of containerization of System 3 is the most expensive of the three systems at all tolerance levels, however the cost gap between System 3 and the other two IP Supply Chain systems lessens as tolerances get tighter, since containerization is less sensitive to diminishing tolerance levels. However, even though the tolerance-sensitive IP costs narrow between containerization and the two elevator systems, total aggregate costs of producing, shipping and handling CWRS wheat from the farm in Central Alberta to port in Vancouver are still notably higher for containerization. Supply Chain System 2 is effectively the least cost supply system at all the tolerance levels considered in this study.

In the context of questions pertaining to the feasibility of meeting the requirements for the specified tolerance levels at the different stages of the three supply chains, assuming price premiums adequate for the functioning of each system, several interesting observations can be noted. At the farm level, ten of the fourteen participating seed growers stated that they were confident that they could meet the requirements for non-GM IP wheat at the lowest of the presented tolerance levels of 0.1 percent. At the primary elevator level, six out of seven operations managers indicated that at 1 percent tolerance or higher, they could credibly segregate GM and non-GM wheat within the same elevator system using the same pit and leg. Below a tolerance level of 1 percent, a designated elevator system would be essential to successfully meet the IP tolerance requirements for GM content in non-GM wheat. However, the elevator operators considered that maintenance of non-GM IP wheat at the tolerance level of 0.1 percent level would be readily achieved within a designated elevator system. From the perspective of elevator operators, containerization would only be necessary at a tolerance level at or close to zero, or if a purchaser specifically required containerization in their contract.

All three responding export elevator managers indicated that even at a 0.1 percent tolerance level, an elevator could still receive both GM and non-GM wheat and be successful in meeting the IP requirements for the non-GM wheat. Elevator operators stated containerization not to be a necessity in order to stay within the tolerance for GM content, unless there was zero or near zero tolerance. However, at zero tolerance, farmers would be unlikely to enter into a non-GM IP contract because they could not be confident that they could meet such a requirement in the circumstances of widespread GM production. Overall, containerization at the farm-gate may only be necessary to satisfy tolerance levels of less than 0.1 percent for GM content.

From the assessments of the various respondents, it appears that participants at all levels of the various supply chains would be disposed to enter into a contract for growing or handling non-GM IP wheat, as long as the premiums were high enough to provide the incentive to do so, and as long as tolerance levels were 0.1 percent or higher.

6.2 Limitations of the Study

As with most studies, there are limitations to this type of research. This study was designed to focus on varying tolerance levels in the context of three different supply chain systems. Some assumptions of the study condition the analysis. These include the assumption that 50 percent of Western Canada's CWRS would be subject to IP procedures that would ensure that this proportion of non-GM wheat would be exported. While this may be a realistic medium-term scenario, variation in the demand for non-GM wheat in terms of its relative volume and the proportion that it constitutes of total demand for Canadian wheat could have a substantially different effect on the estimated costs for the different IP systems. For example, if only 5 percent of the demand for Western Canadian wheat was for non-GM product, the per unit costs of handling this low volume could be higher, with more inefficiency at the elevator level, since smaller segregations would involve more shuffling of grain between bins, increasing the risk of adventitious co-mingling, and the possibility of bins not being used to their capacity would be greater (Harris, 2002). According to the elevator-level interviews for this study with survey participants, the ability to designate one pit or one leg of an elevator strictly to non-GM wheat during a busy season would also be much more difficult if the amount of IP wheat being received was a drastically less than the amount of non-IP wheat. If a complete system was to be designated to non-GM wheat only, and not used to its capacity, this could be the source of inefficiencies in the under-utilized non-GM segment and add to transport costs for the entire wheat marketing system. Additionally, this could cause further inefficiencies in intensifying throughput in non-IP systems, and push these into over-capacity situations.

Certain biases may be present in research studies where people are asked to provide estimates or otherwise respond to a hypothetical situation. Two types of bias that may arise in this situation include strategic bias and hypothetical bias (Bishop and Heberlein, 1979). Strategic bias may be a factor if the hypothetical scenario involves a situation where the respondents feel that their response may have an effect on some policy or decision that is implemented in the future. In considering the commercialization of GM wheat, hypothetical bias cannot be ruled out and may have been a possible factor. Hypothetical bias exists when respondents perceive the situation to be hypothetical and not real, and as a result respond in a manner that is less likely to be accurate than if they felt the situation was realistic. Attempts were made to develop a scenario for the study that appeared to be a realistic situation, in order to diminish the likelihood of hypothetical bias in responses.

Due to the broad scope of the study, three hypothetical supply chains were considered from the levels of farm to port, giving a challenge to reach desirable depths of scrutiny at each level. Attempts were made to analyze each stage as fully as possible under the given time restraints. To achieve this, focus was placed on the incremental costs to the existing base situation of current handling and marketing arrangements, relative to the postulated scenario of the study. More precise estimates of the total costs of different supply chains may be achieved by directly costing these, rather than following an incremental costing procedure.

6.3 Suggestions for Further Research

Additional research could focus on actual data for non-GM IP wheat costs if and when GM wheat is released for more precise analysis of IP costs at different tolerance levels. Additionally, the impact of differing tolerance levels on the specified supply chains could be examined through to the end consumer, to capture any additional IP costs that may exist beyond the designated Canadian export port. Further detailed investigation of costs at each stage in the various supply chains could also be conducted to focus on total, rather than incremental, costs of IP systems.

There are some intriguing issues that could be considered in future studies pertaining to non-GM and GM identity preservation systems and procedures. These could involve consideration of future technological developments that may decrease the cost of IP and/or decrease the likelihood of adventitious co-mingling. There has been some usage of "coloured" varieties of wheat for certain experiments involving gene flow. It has been suggested that if different GM varieties were to be commercialized where the GM trait would always carry with it a distinguishable phenotype, this could reduce the need for GM testing and the current Western Canadian KVD system could remain in place (Johnson, 2003).

Terminator gene technology could also reduce costs and risks of contamination, and this may be of particular importance for GM crop varieties with pharmaceutical, neutraceutical and industrial traits that may be harmful to humans or animals

(Johnson, 2003). Terminator technology involves seed that is not viable, eliminating the problem of volunteer GM crops because any seed left in the field would not grow, but raising a potential concern that the technology might transfer to other plants. According to an interview with an employee of an agricultural-biotechnology developer, some possibilities that are being studied involve situations in which the GM trait is expressed or carried in the chloroplast, where it would not out-cross to other plants. This possibility could appreciably diminish the need for isolation zones, subject to assurance that GM fields and non-GM fields did not overlap. With further biological and socio-economic research, future IP costs for non-GM wheat could potentially be reduced. The possibilities of new and refined technologies are stimulating, and the need for research is great. New agricultural technologies are not without challenges, but are examples of the need for research and development that needs to be undertaken in order to cater to the preferences of consumers and to maintain the integrity of agricultural systems as new GM crops are developed.

BIBLIOGRAPHY

AAFRD. Alberta Agriculture, Food and Rural Development. 2002-2003a. Available online at:
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex82/$file/100_32-10.pdf?OpenElement

AAFRD. Alberta Agriculture, Food and Rural Development. 2002-2003b. Available online at:
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ6787/$FILE/blk_cereals.gif

AAFRD. 2002. Alberta Agriculture, Food and Rural Development. Publication: Cost Guide, Farm Operations.

Bair, J. 2002. "A Wheaty Issue: GM Wheat Enters the Regulatory Arena." Spotlight. *AgBiotech Buzz.* Available online at: http://pewagbiotech.org/buzz/display.php2?Story ID=96

Bender, K., L. Hill, B. Wenzel, and R. Hornbaker. 1999. "Alternative Market Channels for Specialty Corn and Soybeans." National Grain and Feed Association. Available online at: http://ngfa.org/specialtybk.html.

Bishop, R.C. and T.A. Heberlein. 1979. "Measuring Values of Extramarket Goods: Are Indirect Measures Biased." *American Journal of Agricultural Economics.* v61. Pages 926-930.

Breitkreuz, R. 2002. Alberta Agriculture, Crop Specialist, Edmonton, AB. Personal communication. September 10.

Brown, M. 2003. Non-GM IP soybean grower, certified wheat seed and soybean seed grower, Mitchell, ON. Personal Communication. March 18.

Buckwell, A., G. Brookes and D Bradley. 1998. CEAS Consultants (Wye) Ltd. "Economics of Identity Preservation for Genetically Modified Crops." CEAS 1745/GJB. Wye, England.

Bullock, D. S., M. Desquilbet, and E. Nitsi. 2000. "The Economics of Non-GMO Segregation and Identity Preservation." Presented paper at American Agricultural Economic Association Meeting, Tampa Bay, FL.

CGC. Canadian Grain Commission. 2003. Frequently asked questions. Available online at: http://www.grainscanada.gc.ca/.

Cobb, N. 2003. Canadian Wheat Board, Winnipeg, MB. Personal Communication. August 12.

Coppock, D. 2002. "A Wheaty Issue: GM Wheat Enters the Regulatory Arena." Spotlight. *Agbiotech Buzz*. Available online at: http://pewagbiotech.org/buzz/display.php2?StoryID=96

Cramer, L. 2000. "Agricultural Biotechnology: An Introduction to the Growing Debate." Available online at: www.foodaidmanagement.org/worddocs/environmentwg/agbiotech.doc

CSGA. Canadian Seed Growers' Association. 2002. "Regulations and Procedures for Pedigreed Seed Crop Production." Circular 6-94.

CWB. Canadian Wheat Board. 2003. Historical Statistics. Available at: http://www.cwb.ca/en/topics/trade_issues/historical_statistics.jsp

CWB. Canadian Wheat Board. 2002. "Agronomic Assessment of Roundup Ready® Wheat." Available online at: http://www.cwb.ca

CGC and CWB (Canadian Grain Commission and Canadian Wheat Board). 2000. "Western Canada's Wheat Quality Control System: Future Directions." Available online at: http://www.cgc.ca

Daoust, L. 2003. Canadian National Rail, Account Development Group. Personal Communication. July 17.

Dobson, C. 2002. "Canada and Identity Preservation Systems for Non-Genetically Modified Canola." MSc. Agriculture Economics Thesis. University of Saskatchewan.

Demeke, T. 2002. Canadian Grain Commission, Winnipeg, MB. Personal communication. May 9.

Deweerd, W. 2003. Hard Red IP wheat and non-GM IP soybean grower, Stratford, ON. Personal Communication. March 21, 25.

Food Future. 2002. Informing Consumers about Genetic Modification: "What are GM Crops?" Available online at: http://www.foodfuture.org.uk/gmcrops/whataregmcrops.htm

Fowler, J. 2003. MANA International. Personal Communication. July 17.

Gene Scan Inc. 2003. GMO-testing. Available online at: http://www.gmotesting.com/

Gosnell, D. 2001. "A Comparative Cost-Analysis of Segregation Options for Non-GM Wheat in Western Canada." MSc. Agriculture Economics Thesis. University of Saskatchewan.

Goyeau, G. 2003. Alberta Agriculture, Logistics Specialist, Edmonton, AB. Personal Communication. July 16, 17.

Green, A. and P. Salisbury. 2001. "Novel plant products from gene technology." Proceedings of the 10th Australian Agronomy Conference, Hobart. 2001.

Grenier, M. 2003. Canadian Wheat Board. Herbicide Tolerant Crops Conference, Saskatoon, SK, March 18, 19.

Haarsma, D. 2003. Certified Seed Grower, IP Canola Grower, Malt Barley Grower and Seed Potato Grower, Stony Plain, AB. Personal Communication. June 5.

Harris, R. 2002. Elevator and Marketing Manager and IP Soy Coordinator, Perth County Co-op, Mitchell, ON. Personal Communication. August 12.

Hobbs, J. E. and M. D. Plunkett. 1999. "Genetically Modified Foods: Consumer Issues and the Role of Information Asymmetry." *Canadian Journal of Agricultural Economics*, Vol. 47 (4), pp. 445-455.

Hucl, P., and M. Matus-Cadiz. 2001. "Isolation distances for minimizing out-crossing in spring wheat." *Crops Science* 41: pp. 1348-1351.

Johnson, L. 2003. Former CSGA president and Saskatchewan seed grower. Personal communication, Herbicide Tolerant Crops Conference, Saskatoon, SK. March 18.

Kalaitzandonakes, N. and R. Maltsbarger. 1998. "Biotechnology and Identity-Preserved Supply Chains: A look at the Future of Crop Production and Marketing." *Choices*, 4th Quarter. Pp 5-18.

Kennet, J. 1997. "An Examination of Bread Wheat Quality and its Effect on Vertical Co-Ordination in the Wheat Supply Chain." MSc. Agriculture Economics Thesis. University of Saskatchewan.

Lin, W. W., W. Chambers, and J. Harwood. 2000. "Biotechnology: U.S. Grain Handlers Look Ahead." *Agricultural Outlook*. Economic Research Service, U.S. Department of Agriculture, AGO-270.

Maltsbarger, R. and N. Kalaitzandonakes. 2000. "Direct and hidden costs in identity preserved supply chains." *AgBioForum*, 3(4), 236-242. Available online at: http://www.agbioforum.org.

Mauro, I. and R. Van Acker. 2003. "Planting Seeds of Doubt." Genetically modified crops forum. University of Alberta, Edmonton, AB. March 11.

Neogen Corporation. 2001. Agri-Screen CP4 Roundup Ready® Strip Test: Product Information Sheet. Information Available online at: http://www.neogen.com.

Philips, P. and H. Foster. 2000. "Labeling for GM Foods: Theory and Practice." Dept. of Agricultural Economics, University of Saskatchewan. Available online at: http://www.cabi-publishing.org/Bookshop/ReadingRoom/085199573x/085199573xCh20.pdf

Philips, P. and H. McNeil. 2000. "A Survey of National Labeling Policies For GM Foods." *Agbioforum* -- Volume 3, Number 4 -- 2000. Pages 219-224.

Querci, M., M. Mazzara. 2001. "Characteristics of Roundup Ready® Soybean, MON810 Maize, and Bt-176 Maize." Session 7: The Analysis of Food Samples for the Presence of Genetically Modified Organisms. Available online at: http://gmotraining.jrc.it/docs/Session percent207.pdf

Reid, J. 2003. C&M Seeds, IP Wheat Coordinator, Palmerston, ON. Personal Communication. April 29.

Roederer, C., R. Nugent, and P. Wilson. 2000. "Economic Impacts of Genetically Modified Crops on the Agri-Food Sector: A Synthesis." Directorate-General for Agriculture, working document.

Smith, K. 2003. Gene Scan U.S.A. New Orleans, LA. Personal Communication. January 22.

Snider, S. 2003. Little Red Hen Mills, New Norway, AB. Personal Communication. July 22, 23.

Sorenson, N. 2001. "Is GMO free production possible? Costs and methods of crop segregation." Institute for Agriculture and Trade Policy. Available online at: http://www.cropchoice.com.

Sparks Companies Limited. 2000. "The IP Future: Identity Preservation in North American Agriculture." Sparks Company, Memphis, TN and Winnipeg, MB.

Spurrier, R. 2003. Customer Service, Genetic-ID, Fairfield, Iowa. September 20, 2003.

Sundstrom, F.J., J. Williams, A. Van Deynze and K. J. Bradford. 2002. "Identity Preservation of Agricultural Commodities." Agricultural Biotechnology in California Series. Publication 8077.

Van Acker, R.C., A.L. Brule-Babel, and L.F. Friesen. 2003. "An Environmental Safety Assessment of Roundup Ready® Wheat: Risks for Direct Seeding Systems in Western Canada." Report for The Canadian Wheat Board, For submission to: Plant Biosafety Office of the Canadian Food Inspection Agency.

Vandeburg, J. M., J. R. Rulton, G. J. Dooley, and P. P. V. 1999. "Impact of Identity Preservation of non-GMO Crops on the Grain Market System." Presented Paper at The Economics of Quality Control in Agriculture Conference, Saskatoon, SK.

Vanderkylen, R. 2003. Perth County Co-op, Mithcell, ON. Personal Communication. April 16.

Veeman, M. 2001. "Consumers, Public Perceptions and Biotechnology." University of Alberta, Rural Economy Staff Paper.

Vyn, R. 2003. Alberta Agriculture, Agronomist, Edmonton, AB. Personal communication. February 25, 2003.

Waines, J. G., and S. G. Hegde. 2003. "Intra-specific gene flow in bread wheats as affected by reproductive biology and pollination ecology of wheat flowers." *Crop Science* 43: pp. 451-463.

Wilson, W. W., and B. L. Dahl. 2002. "Costs and Risks of Testing and Segregating GM Wheat." Agribusiness and Applied Economics Report No. 501, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND.

Wisner, Dr. R. 2002. "GMO Spring Wheat: Its potential short-term impacts on U.S. wheat export markets and prices." Iowa State University. Available online at: http://www.northernplains.org/media/2003/Wisner-Final-Report-3-11-03.pdf

Young, C. 2003. Seed Production Manager, Snobelen Farms Ltd., Lucknow, ON. Personal Communication. April 16.

Appendix A – Survey Questionnaires
Appendix A1

Interview/Questionnaire: **Seed Growers/Producers**
Interviewer: Izzy Huygen, University of Alberta

Seed Growers (representing producers of non-GM Identity Preserved (IP) wheat)

Scenario:
Round-up Ready wheat has been commercialized in Canada. Export markets demand non-GM wheat from Canada creating the need to develop an Identity Preservation system in order to ensure that they receive non-GM wheat. You have decided to grow non-GM wheat for export, and this wheat must be Identity Preserved.

- This research seeks to estimate how costs of identity preserving non-GM wheat will change according to different tolerance levels that export customers specify.
- Tolerance level refers to the percentage of GM content that is accepted in non-GM Identity Preserved wheat consignments.
- For the purpose of this study, there are certain assumptions that we have made in the development of an "average farm" model. Wherever possible, please try to give your estimates based on this average farm model.

Assumptions for our "average" farm model:

- Average yield for CWRS is 50 bushels per acre.
- The typical field size is one-quarter section (160 acres)
- Producer bin sizes for storing non-GM wheat are 8000 bushels
- Producers use tractor trailer (semi) to ship grain off farm, 40 tonne legal capacity
- Producers use a truck (400-600 bu.) to haul wheat from field to storage bins
- Producer uses typical augers, combine and dryer to handle non-GM wheat

Your Operation

1. Please indicate the following for **your** farm:

- What is your total farm acreage? __________
- Acreage of CWRS wheat that you typically grow? __________
- How much of your CWRS wheat is typically IP? (seed etc.) __________

Isolation Zones
The next three questions pertain to your isolation zone practices for a typical 160 acre field of non-GM IP wheat.

2. How many sides of your typical non-GM wheat IP field would you need to manage an isolation zone at each tolerance level? (Considering that some of the boundaries are naturally isolated).

- 5% ___________
- 3% ___________
- 1% ___________
- .5% ___________
- .1% ___________

3. Please describe your isolation zone practices for each of the following tolerance levels. Also, please indicate what would be the estimated cost of implementing each of the strategies for each tolerance level? (Consider management, time, loss of income or any other cost that you might incur. Please mention which factors contribute to the cost)

	Isolation Type and distance	Costs Involved
eg. .5%	10 metre tilled buffer strip.	e.g. opportunity cost on land, management expenses (time etc.), lost premium for IP wheat that is sold as non-IP wheat etc.
eg. 3%	Harvest 10 metres of outside and market as non-IP wheat (2 sides of field)	Lost IP premium for xx bushels (xx acres X 50 bushels/acre) of wheat.
5%		
3%		
1%		
.5%		
.1%		

Explain or comment if necessary.

Volunteers

4. What would the **additional costs** be in controlling volunteer Round-up Ready wheat in your non-GM wheat field? Please explain how you would control volunteers (tillage, rotation, additional herbicide etc.) in your operation for each tolerance level. Also mention whether you would use a no-till, minimum-till or conventional tillage system.

- 5% ___________
- 3% ___________
- 1% ___________
- .5% ___________
- .1% ___________

Additional comments:

Cleaning Costs

5a. What type (air or drill) and size (width and grain tank capacity) is your seeder?____

5b. How long would it take to clean your **seeder** and seeder filling auger if applicable (minutes) for each of the different tolerance levels?

- 5% ___________
- 3% ___________
- 1% ___________
- .5% ___________
- .1% ___________

Consider the following three methods for cleaning your combine when answering the following question.

A. Rigorous cleaning -- Carefully cleaning the combine, attempting to remove practically all the leftover grain throughout the machine.
B. Quick cleaning -- Removing the majority of the grain where it accumulates in the largest volumes such as in the grain tank and the rock trap.
C. Flushing – Harvesting a small amount of the IP grain and dumping it separate from what will be sold as IP.

6. Please indicate **which method** or **combination of methods** you would use to clean your combine at each of the tolerance levels. Indicate if you would flush more than once, and indicate how many bushels approximately you would flush through.
   eg. 5% -- B(quick clean), C(flush 30 bushels)
   eg. .5% -- A(rigourous clean), C(flush 70 bushels), C(flush 60 bushels)

   - 5% ___________
   - 3% ___________
   - 1% ___________
   - .5% ___________
   - .1% ___________

7. How long (minutes) would method A (rigorous cleaning) take one person to complete on your combine? _____________

8. How long (minutes) would method B (quick cleaning) take one person to complete on your combine? _____________

9. Is added time involved with one flush (30 bushels) and dump of the combine as in method C? If yes, please explain.

10. How much time (minutes) would it take for one person to clean out your grain truck for each of the tolerance levels?
    - 5% ___________
    - 3% ___________
    - 1% ___________
    - .5% ___________
    - .1% ___________

11. How much time (minutes) would it take for one person to clean out your semi for each of the tolerance levels?
    - 5% ___________
    - 3% ___________
    - 1% ___________
    - .5% ___________
    - .1% ___________

12. How much time (minutes) would it take for one person to clean out your bin for each of the different tolerance levels?

8000 bushel bin

- 5% ____________
- 3% ____________
- 1% ____________
- .5% ____________
- .1% ____________

13. How much time (minutes) would it take for one person to clean out your auger and auger boot at each of the different tolerance levels? Please explain the process as well.

- 5% ____________
- 3% ____________
- 1% ____________
- .5% ____________
- .1% ____________

14a. What is the capacity and type of dryer that you use for your wheat?

____

14b. How much time (minutes) would it take to clean the dryer for each of the different tolerance levels?

- 5% ____________
- 3% ____________
- 1% ____________
- .5% ____________
- .1% ____________

Comments:

15. At what tolerance level would you feel that you would not consider growing non-GM wheat, despite an acceptable premium, because it would be too difficult or too risky or even impossible to do?

16. Please comment on any other cost points in a non-GM IP wheat system on your farm that may be affected by different tolerance levels.

Appendix A2

Interview/Questionnaire: Primary Elevator Operations-Managers
Interviewer: Izzy Huygen, University of Alberta

Scenario:

Round-up ready wheat has been commercialized and has been adopted by farmers in your area. There is market demand for non-GM identity preserved (IP) wheat. You have decided to receive non-GM IP contracted wheat, and maintain an IP system for it.

Objective

This study's purpose is to consider how the effects of tolerance levels for allowable GM content within non-GM wheat will affect the costs of running the IP system. The tolerance levels that have been selected for analysis are: 5%, 3%, 1%, .5% and .1%. You have been asked as an elevator operator/IP coordinator to estimate how these tolerance levels might affect your operations.

Assumptions:

- Of the current amount of CWRS wheat grown in the area 50% will be non-GM IP based on the fact that most current customers of CWRS wheat have indicated that they will not accept GM wheat at this time.
- There will be three different IP system alternatives considered:
    1. Segregation within elevator -- GM wheat and non-GM wheat received at same elevator and kept separate within.
    2. Designated elevator – Specific elevators will be designated non-GM for Identity Preserved wheat and will not receive any GM wheat.
    3. Containerization -- IP wheat will be containerized on the farm and remain containerized until it reaches the processor.

Please give your best estimate for the following questions.

1. What is the storage capacity of your elevator? ____________
2. How much wheat do you typically receive in a year? ____________
3. How much of that wheat is CWRS? ____________
4. How much of your received CWRS is for human consumption? ____________
5. How much of you're the amount in #4 is for export? ____________

Cleaning

6. What is the typical size of your storage bins/silos?________________________

For the next two questions, you are asked to indicate the approximate amount of additional time needed beyond what you would normally spend on cleaning at each tolerance level and for each IP system. Part a will be used to associate a labour cost with the time spent cleaning, while part b will be used to link that labour cost to a certain volume of wheat (i.e. $1.00 per tonne for cleaning costs).

Please indicate the **additional** time (minutes) needed to clean the system at each tolerance level.

7. a. IP system: non-GM and GM segregated within the same elevator

	Receiving Pit/Leg/Bins	Storage Bin/Silo	Shipping (legs etc.)
5%			
3%			
1%			
.5%			
.1%			

7. b. How often would you estimate that you would have to clean the system?
(e.g. Once before receiving 3000 tonnes of IP wheat).

8. a. IP system: Designated non-GM elevator

	Receiving Pit/Leg/Bins	Storage Bin/Silo	Shipping (legs etc.)
5%			
3%			
1%			
.5%			
.1%			

8. b. How often would you estimate that you would have to clean the system?
(e.g. once per 8000 tonnes of IP wheat………..or never).

Additional Expenditures

9. What additional capital expenses would you incur at the different tolerance levels in order to prevent co-mingling of non-GM and GM wheat if you were segregating within the same elevator? Would additional labour need to be hired in order to "run" the additional equipment?

Expense Item Cost

5% ______________________________
3% ______________________________
1% ______________________________
.5% ______________________________
.1% ______________________________

Explain if necessary:

10. Please comment on any other associated IP costs that you would face that may significantly change with different tolerance levels.

11. At what tolerance level would you anticipate that a designated elevator would be necessary in order to ensure purity in the non-GM wheat IP system? That is, at which of the five listed tolerance levels (5%, 3%, 1%, .5% and .1%) would you no longer consider receiving both GM and IP non-GM wheat through the same elevation system? Comment or explain if necessary.

12. At what tolerance level (5%, 3%, 1%, .5% or .1%), if at all, would you anticipate that containerization from the farm would become necessary, as opposed to using an elevator facility, to ensure that non-GM wheat IP wheat could meet the required tolerance level? Comment or explain if necessary.

Appendix A3

Interview/Questionnaire: **GM Testing Specialists – Cost Estimations**
Interviewer: Izzy Huygen, University of Alberta

Testing for GM Content in non-GM Wheat

Scenario:
Round-up ready wheat has been commercialized and has been adopted by farmers in Western Canada. There is market demand for non-GM identity preserved (IP) wheat. This non-GM IP wheat is destined for export and must be tested for GM content.

Objective
This study's purpose is to consider how the effects of tolerance levels for allowable GM content within non-GM wheat will affect the costs of running the IP system. The tolerance levels that have been selected for analysis are: 5%, 3%, 1%, .5% and .1%. You have been asked as someone who is familiar with current GM testing methods and costs to estimate how much various GM tests would cost for wheat.

Please give your best estimate for the following:

1. Please indicate the costs per test for each of the following GM tests and indicate if the costs would be similar or the same if these tests were used in testing for GM content in non-GM wheat.

Strip Test: ____________________

ELISA (Plate Test): ____________________

PCR: ____________________

Comments:

Appendix A4

Interview/Questionnaire: GM Testing Specialists/IP Coordinators – Estimating GM Testing Protocol for non-GM Wheat
Interviewer: Izzy Huygen, University of Alberta

Testing for GM Content in non-GM Wheat

Scenario:
Round-up ready wheat has been commercialized and has been adopted by farmers in Western Canada. There is market demand for non-GM identity preserved (IP) wheat. This non-GM IP wheat is destined for export and must be tested for GM content.

Objective
This study's purpose is to consider how the effects of tolerance levels for allowable GM content within non-GM wheat will affect the costs of running the IP system. The tolerance levels that have been selected for analysis are: 5%, 3%, 1%, .5% and .1%. You have been asked as someone who is familiar with current GM testing methods and Identity Preservation protocol for Soybeans to estimate GM testing strategies for non-GM wheat across different tolerance levels, and for three alternate IP supply chains.

1. Please consider the three alternate systems and the assumptions of this study in looking at the attached worksheet. When the interviewer calls to discuss your estimates for what GM testing protocols would look like, the questions will be based on the worksheet. Please feel free to ask any questions or make any comments at the time of the interview, or previous to the interview if you desire.

System 1 – Elevators receive GM and non-GM wheat.

Farm (220 tonnes storage)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Primary Elevator (incoming 25 tonne lot)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Primary Elevator (outoing 90 tonne lot)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Export Elevator (incoming 90 tonne average rail car)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Export Elevator (outgoing 32000 tonne average vessel shipment)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

System 2 – Elevators receive only non-GM wheat.

Farm (220 tonnes storage)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Primary Elevator (incoming 25 tonne lot)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Primary Elevator (outoing 90 tonne rail car)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Export Elevator (incoming 90 tonne average rail car)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Export Elevator (outgoing 32000 tonne average vessel shipment)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

System 3 – Containerization

Farm (220 tonnes storage)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Container (27 tonnes, loaded on farm)

	Type of Test	# of Tests	Cost per Test
5%			
3%			
1%			
0.5%			
0.1%			

Appendix A5

Interview/Questionnaire: Export Elevator Operations-Managers
Interviewer: Izzy Huygen, University of Alberta

Scenario:
Round-up ready wheat has been commercialized and has been adopted by farmers in the Canadian prairies. There is export market demand for non-GM identity preserved (IP) wheat. You have decided to receive non-GM IP wheat, and maintain an IP system for it.

Objective
This study's purpose is to consider how the effects of tolerance levels for allowable GM content within non-GM wheat will affect the costs of running three alternate IP systems. The tolerance levels that have been selected for analysis are: 5%, 3%, 1%, 0.5% and 0.1%. You have been asked as an export elevator operator / IP coordinator to estimate how these tolerance levels might affect the costs for tolerance sensitive IP procedures.

Assumptions:

- Genetically modified (GM), Round-up Ready wheat is commercialized in Canada. Approximately half of the CWRS grown in the Canadian prairies is devoted to non-GM Identity Preserved wheat for export.
- Tolerance levels refer to the percentage of GM content that is allowed in non-GM IP wheat shipments
- There will be one of the five listed tolerance levels specified for non-GMO wheat that is to be Identity Preserved. We are asking what the costs might look like under each different tolerance level exclusively, that is, we are assuming that there are not segregations for multiple tolerance levels simultaneously .
- There are three different IP system alternatives considered:
    1. Segregation within elevators – Both GM wheat and non-GM wheat are received at primary and export elevators and kept separate within.
    2. Designated elevators – Specific elevators will be designated as non-GM only and will not receive any GM wheat into the same system.
    3. Containerization -- IP wheat will be containerized on the farm and remain containerized until it reaches the importing customer.

Please give your best estimates for the following questions.

1. What is the storage capacity of your elevator? ____________
2. How much wheat do you typically receive in a year? ____________
3. How much of your annual received is CWRS? ____________
4. How much of your received CWRS is for human consumption? ____________
5. What is the typical wage for labourers who would be involved in cleaning the elevator system to ensure IP? ____________

Cleaning

6. What is the typical size of your storage bins/silos? ____________________

For the next two questions, you are asked to indicate the approximate amount of additional time needed beyond what you would normally spend on cleaning at each tolerance level and for each IP system. Part a will be used to associate a labour cost with the time spent cleaning, while part b will be used to link that labour cost to a certain volume of wheat (i.e. $1.00 per tonne for cleaning costs).

Please indicate the **additional time** needed to clean the system at each tolerance level.

7. a. IP system: non-GM and GM segregated within the same elevator

Receiving (pit/leg etc.) Typical Storage Bin/Silo Shipping (legs etc.)

5% ____
3% ____
1% ____
.5% ____
.1% ____

b. How often would you estimate that you would have to clean the system?
(e.g. Once before receiving 3000(5000, 10000 etc.) tonnes of IP wheat).

8. a. IP system: Designated non-GM elevator

Receiving (pit/leg etc.) Typical Storage Bin/Silo Shipping (legs etc.)

5% ____
3% ____
1% ____
.5% ____
.1% ____

b. How often would you estimate that you would have to clean the system?
(e.g. once per 8000 (10000, 20000) tonnes of IP wheat or; once per year or; never).

Additional Expenditures

9. What additional **capital expenses** would you incur at the different tolerance levels in order to prevent co-mingling of non-GM and GM wheat if you were segregating within the same elevator? Would additional labour need to be hired in order to "run" the additional equipment?

	Expense Item	Cost	Additional Labour
5%			
3%			
1%			
.5%			
.1%			

Explain if necessary:

10. Please comment on any other associated IP costs that you would face that may significantly change with different tolerance levels.

11. At what tolerance level would you anticipate that a designated elevator would be necessary in order to ensure purity in the non-GM wheat IP system? That is, at which of the five listed tolerance levels (5%, 3%, 1%, .5% and .1%) would you no longer consider receiving both GM and IP non-GM wheat through the same elevation system? Comment or explain if necessary.

12. At what tolerance level (5%, 3%, 1%, .5% or .1%), if at all, would you anticipate that containerization from the farm would become necessary, as opposed to using an elevator handling facility, to ensure that non-GM wheat IP wheat could meet the required tolerance level? Comment or explain if necessary.

Appendix A6

Interview/Questionnaire: Plant Scientists/Agronomists
Interviewer: Izzy Huygen, University of Alberta

The following questions are part of a research study designed to estimate how tolerance levels for genetically modified (GM) wheat will affect the costs of identity preservation (IP) for non-GM wheat. Specific tolerance levels will be given; referring to how much GM content will be permitted in a consignment of non-GM wheat.

This portion of the questionnaire deals with some of the scientific specifics regarding Round-up Ready® (RR) wheat, which in all likelihood will be the first GM wheat commercially available in Canada.

Please give your best estimates to the following questions. If you cannot answer a question, please indicate N/A.

Isolation Zones

1. What distance (specify units) do you believe will be required for an isolation strip around an IP non-GM wheat field at each of the following specified GM tolerance levels? (i.e. 1% means no more than 1% GM content allowed in non-GM wheat)

   - 5% ___________
   - 3% ___________
   - 1% ___________
   - .5% ___________
   - .1% ___________

2. Please describe the type of isolation zone that a non-GM wheat IP system might require at each of the specified GM tolerance levels?

   - 5% ____
   - 3% ____
   - 1% ____
   - .5% ____
   - .1% ____

   Do you have any additional comments on isolation zones?

3. What rotational or chemical practices will be necessary following a GM wheat crop to prevent contamination of other crops with wheat volunteers or subsequent wheat crops at each of the following tolerance levels?

   - 5%
   - 3%
   - 1%
   - .5%
   - .1%

4. Will terminator gene technology be a viable option for GM wheat? Please explain.

   If yes, does it eliminate the concern for pollen drift?

   If yes, does it eliminate the concern for volunteer Round-up Ready wheat?

5. Are other technological mitigation procedures valid for reducing gene flow in wheat crops?

If yes, what will be the benefits of that particular technology in decreasing the likelihood of GM contamination of other crops?

6. Are there any additional concerns or comments that you would like to express concerning any other significant issues when considering contamination of non-GM IP wheat with GM wheat?

7. What other GM traits are on the horizon for wheat?

Appendix A7

Interview/Questionnaire: Agricultural-Biotechnology Developers
Interviewer: Izzy Huygen, University of Alberta

The following questions are part of a research study designed to estimate how tolerance levels will affect the costs of identity preservation (IP) for wheat.

Assumptions:

-Genetically Modified (GM) Round-up Ready® (RR) wheat is commercialized in Canada. Approximately half of the CWRS (Canadian Western Red Spring) grown in the Canadian prairies remains non-GM wheat.

This portion of the questionnaire deals specifically with some of the specifics regarding Roundup Ready ® wheat, which in all likelihood will be the first GM wheat commercially available in Canada.

Please give your best estimates for the following questions.

1. Is it likely that other types of Round-up Ready® wheat will follow RR CWRS in the prairies? Please explain.

2. What specific varieties (cultivars) of GM wheat is Monsanto planning to commercialize with the RR gene?

3. What are the regulatory requirements that you are meeting on gene flow prior to the release of Round-up Ready wheat?

4. Do you know what other GM traits are on the horizon for wheat?

Appendix A8

Interview/Questionnaire: Containerization
Interviewer: Izzy Huygen, University of Alberta

The following questions are part of a thesis research study designed to estimate how tolerance levels will affect the costs of identity preservation (IP) for non-GM wheat.

Assumptions:

-GM Round-up Ready wheat is commercialized in Canada. Approximately half of the CWRS grown in the Canadian prairies is devoted to non-GM Identity Preserved contract wheat.

-Tolerance levels refer to % of GM content allowed in non-GM IP wheat shipments

-There will be one of the five listed tolerance levels specified for non-GM wheat that is to be Identity Preserved. We are asking what the costs might look like under each different tolerance level exclusively, that is, we are not assuming that there will be segregations for each tolerance level.

-Several different supply chains are being looked at including:

1. Segregation of non-GM and GM (commodity) wheat within elevator facilities,
2. Designation of facilities as either non-GM or GM; and
3. Containerization.

This portion of the questionnaire deals specifically with containerization. The tolerance levels refer to the maximum allowable amount of GM wheat in a delivery of non-GM wheat.

Please give your best estimate for the following questions (feel free to use the back of this page if necessary). Please skip any questions that are not relevant to your experience with containerization.

1. Please describe your experience with containerization.

2. What was the circumstance that prompted you to use a container system?

3. At what tolerance level would you anticipate that containerization would become necessary to ensure purity in a non-GM wheat IP system? (Please check one)
   - 5%___
   - 3%___
   - 1%___
   - 0.5%___
   - 0.1%___

4. Please describe the process that was involved (e.g., source of containers, how handled, manner of shipping, sampling and quality control procedures, etc.)?

5. If possible, indicate the level of GM tolerance you have would be able to achieve for a non-GM wheat IP system using containers (check one):
   - 5%___
   - 3%___
   - 1%___
   - 0.5%___
   - 0.1%___

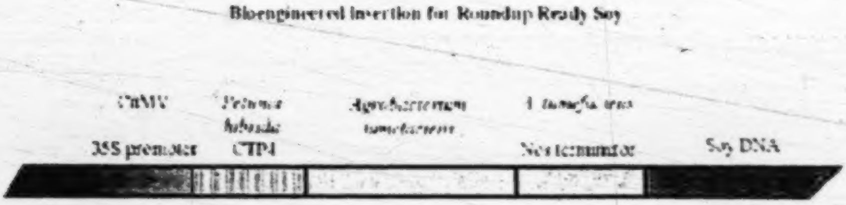
6. Please give any additional comments you may have concerning containerization (e.g., buyback costs, satisfaction with the process, ease of management of process, impediments to containerization, legal and logistical issues, etc.)

Appendix B: Genetic Modification Details

Regardless of the genetically modified (GM) trait in question, the recombinant DNA (rDNA) materials that are inserted into a host plant genome (using genetic engineering), has certain genetic elements in common. The inserted genetic sequence of DNA is made up of at least a promoter, a protein-coding site and a terminator. The promoter acts as an on-switch for the copying of DNA into messenger RNA (mRNA). The terminator indicates the end point for this copying process. The structural gene governs which specific protein is produced and thus, which GM trait the plant will possess (Gene Scan Inc. 2003).

For RR soybeans in particular, a promoter "35S," is derived from the cauliflower mosaic virus. The novel protein that gives the soybeans resistance to Roundup is called "EPSPS," taken from a soil bacterium. The terminator used in the RR soybean's GM construct originates from the same soil bacterium as well (Querci, Mazzara, 2001). Figure B-1 depicts the genetic sequence for the RR gene for soybeans (which will be similar for all other RR crops).

Figure B-1


Bioengineered insertion for Roundup Ready Soy
CaMV
35S promoter
Petunia hybrida
CTP4
Agrobacterium tumefaciens
A. tumefaciens
Nos terminator
Soy DNA

Source: Gene Scan USA Inc.

All of Monsanto Inc.'s RR crops contain the "CP4 EPSPS" coding sequence (Neogen, 2001). It is the expression of this same "CP4" protein in RR soybeans, RR corn, RR canola and RR wheat that causes them to be resistant to Roundup®.